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The Rural Science Series

Edited by L. H. Bailey

# BEAN CULTURE

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BEAN CULTURE. *Hardenburg.*

Variety Pencil Pod Black Wax.

# BEAN CULTURE

BY

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# PREFACE

Considering its economic value and multiplicity of forms and uses throughout the world, probably no food crop has been more neglected in agricultural literature than beans. This may be only an illustration of the fact that comparatively little pedagogical interest and scientific experimentation have been accorded this crop. However, there can be no question that with the steadily increasing consumption of beans, with the increasing cost of animal protein foods, and with the ultimate problem of maintaining soil fertility through legume production, the cultivation of beans and its attendant problems will receive increased attention.

This book was prompted by the apparent need for a readily available source of information and practical treatise on all the economic forms of beans grown in the United States and Canada. It is intended alike for the general use of the grower and the handler as well as the teacher and the student of this commodity.

The author has made free use of Bailey's Manual of Cultivated Plants in arriving at taxonomic descriptions and generic and specific nomenclature. The varietal classification and description studies of Irish and of Jarvis published in the Twelfth Annual Report of the Missouri Botanical Garden and in Cornell Experiment Station Bulletin 260, respectively, have been of valuable service in the discussion of varieties. By the use of many of the bulletins and scientific periodicals of agricultural

experiment stations and the United States Department of Agriculture, an attempt has been made to review briefly the more valuable experimental work on the cultural phases of beans. In so doing, the author hopes to point out not only the practical results obtained but also the principles relevant to the problems concerned in order that the latter may be of most use to students of this crop.

Special acknowledgment is due Doctor R. A. Emerson, Doctor F. P. Bussell, and Mr. T. M. Currence of the New York State College of Agriculture for advice and assistance with the chapter on breeding and improvement; to O. C. Curtis of LeRoy, New York, for helpful advice on marketing; to A. T. Ferrell Company, Saginaw, Michigan, for Fig. 25; to Crippen Manufacturing Company, Alma, Michigan, for Fig. 27; to the Department of Vegetable Gardening, New York State College of Agriculture, for Figs. 6, 8, 9, 10, 22, 26, 28, 31, 33, 34, 35 and 36; to the Department of Plant Pathology, New York State College of Agriculture for Figs. 11, 12, 13, 14, 15, 16, 17; to the United States Department of Agriculture for Figs. 18, 19, 20, 21, 23, 24, 32, 37, 38, 39, 40; and to the McGraw-Hill Book Company, Inc., of New York for permission to reproduce Fig. 30. The author has had the benefit of many helpful suggestions from his colleagues Doctor H. C. Thompson, Doctor Paul Work and Professor R. M. Adams of Cornell University. To these and many others who have willingly cooperated in the work, the author expresses his sincere appreciation.

Ithaca, N. Y.
January, 1927.

E. V. Hardenburg.

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# BEAN CULTURE

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## CHAPTER I

### *BEANS AS A WORLD CROP*

Among the many economic genera of plants belonging to the legume family, there is none as important from the standpoint of its use for human food as the seed of the common field or garden bean, *Phaseolus vulgaris*. The major part of this book is devoted to the various phases concerned in the production, handling and marketing of this crop.

The term "bean" has been used so broadly both in writings and in parlance as to make it difficult to define. Most large-seeded legumes, the seeds of which are commonly separated from the pods at maturity for use as food, are classed as either beans or peas. Although beans and peas are terms sometimes used interchangeably, most round-seeded types with trailing or vining habit of growth and many small leaflets are classed as peas. Well-known examples are field peas, cannery peas, garden peas (forms of *Pisum sativum*), and chick-peas (*Cicer arietinum*). Although many varieties of soybeans are round-seeded, this plant is taxonomically not a pea. In contradistinction to peas, beans are most commonly more or less flat-seeded, with herbaceous stems bearing relatively large well-defined trifoliolate leaves (with three leaflets) and with habit of growth varying

from distinctly bushy to trailing and twining. Examples of flat-seeded legumes commonly known as peas are the cowpeas of the southern states and the pigeon-peas grown in Hawaii and other tropics. Strictly speaking, both of these belong to the bean group.

### ORIGIN AND HISTORY

As a food crop, beans occupy a more important place in southern European and Asiatic countries than in America. Broadly speaking, beans may be called the food of the ancients. Various forms of beans still serve as the principal source of protein food for the peasant classes in Old World countries bordering the Mediterranean Sea and the Indian Ocean. Soybeans are used for food in a variety of ways by the yellow race in China and Japan. Lentils and numerous species of Phaseolus are similarly prepared for human sustenance in India and adjacent countries. Beans have played a part in the superstitions, the politics, and the warfare of ancient peoples. Magistrates were elected in Greece and Rome by the casting of beans into helmets. Certain kinds have been credited with medicinal value.

Historical records contain numerous references to the early cultivation and uses of beans of various types. These are in many cases not sufficiently detailed to indicate either the genus or species referred to. Literature records the cultivation of beans, lupines and lentils in the Nile Valley as early as 2000 B. C. Andrews [1] in a recent statistical summary of crop production in foreign countries, lists legume seed used for food with such terms as lupines, lentils, pulse, habas, chick-peas, broad beans,

[1] Andrews, Frank. "Handbook of Foreign Agricultural Statistics." U. S. Dept. Agr. Dept. Bull. 987. Nov. 9, 1921.

wild beans, haricots, dry peas, soybeans, feves, feveroles, and dry edible beans. In the western hemisphere a similar list would include dry field beans, limas, blackeye cowpeas, snap beans, pintoes, teparies, dry peas, broad beans, peanuts, garbanzos or chick-peas, frejoles, pole runners and lupines. All of the above differ mainly in habit of growth, type of foliage and size, shape and color of seed. They are, however, similar in those characteristics common to all typical legumes; namely, the pea-blossom type of flowers, herbaceous to woody stems, more or less well-defined taproot, nitrogen-assimulating bacteria in nodules associated with the fibrous root system, and bi-valved seeds in varying numbers borne in single-celled pods which readily separate into halves at maturity. Although the principal purpose of production of most of these types is to furnish a supply of relatively rich nitrogenous human food for either home comsumption or as a cash crop, certain of them, notably soybeans, cowpeas, peas, broad beans, velvet beans, peanuts, and lupines, are also used for soil improvement and for feeding to live-stock. Neither peas nor peanuts can be classed as beans, hence these will not be given further treatment. The six genera of beans which may be considered of economic importance in the United States are listed with their common synonyms and botanical names as follows:

| NAME | COMMON SYNONYMS | BOTANICAL NAME |
|---|---|---|
| Common field or garden bean | haricot (French)<br>kidney (English)<br>navy (American)<br>habas (Mexican)<br>feijaos (Portugese)<br>frejoles (Spanish)<br>fagiolo (Italian)<br>bohnen (German) | *Phaseolus vulgaris* |

| *Name* | *Common synonyms* | *Botanical name* |
|---|---|---|
| Soybean | Japan pea<br>Soja or soya<br>coffee bean<br>stock pea | *Glycine Max* (*G. hispida or Soja Max*) |
| Cowpea | Southern field pea<br>cow field pea | *Vigna sinensis* |
| Broad bean | Windsor bean<br>horse bean<br>bean of history<br>fava<br>Portuguese bean<br>English bean<br>mazagan | *Vicia Faba* |
| Velvet bean | Florida velvet<br>Georgia velvet<br>speckled bean | *Stizolobium spp.* |
| Garbanzo | chick-pea<br>coffee bean<br>gram<br>Egyptian pea<br>gypsy pea<br>porquero | *Cicer arietinum* |

COMMON FIELD OR GARDEN BEAN, PHASEOLUS SPP.

This is by far the most important group of beans produced in America and includes practically all of the crop listed by the United States Census as dry, edible beans. Since it includes not only the common field and garden varieties of dry, snap and green-shell beans, but also the limas, teparies, and flowering or runner varieties, its climatic adaptations, habit of growth, and cultural requirements are very diverse.

The common bean was formerly thought to have originated in India. Later, however, it became evident that

FIG. 1.—An excellent field of string beans grown as a truck crop near Charleston, S. C.

the so-called Phaseolus of southern Asiatic countries was not identical with that of the western hemisphere. Beans of this type were being grown with corn by the American Indians at the time of the discovery of America. It is now generally conceded that the common bean is indigenous to tropical South America. From this beginning, it has become widely cultivated throughout the western hemisphere and is used mainly in three forms; namely, as snap, green-shell and dry-shell beans.

Irish [1] describes the plants of this genus as follows: "Plant subglabrous, dwarf or climbing 6 feet or more. Leaflets ovate-acuminate, often oblique. Flowers in racemes shorter than the leaves, white or purplish-violet, medium size. Pods flattened to subcylindrical, straight or curved, more or less turgid. Seed variable in size, shape, and color."

Cultural and other commercial aspects of this genus are discussed at length in later chapters.

### VALUE AMONG LEGUMES

The approximate total value of all legumes grown in the United States is slightly more than one billion dollars, according to the Census of 1920. A fair measure of the relative value of the bean crop, notably of dry edible and of cannery beans, compared to other legumes is indicated in Table I.

Unfortunately the United States Census of 1920 does not furnish information on the value of cowpeas. However, it may be assumed that a large proportion of the value given as for annual legumes cut for hay represents cowpeas. Therefore, the combined annual value of the

[1] Irish, H. C. "Garden Beans as Cultivated Esculents." Twelfth Annual Rep., Mo. Bot. Gard. 1901.

types of beans treated in this book approximates $200,000,000 or nearly one-fifth of the value of all legumes grown in the United States.

TABLE I

VALUE OF LEGUMES GROWN IN THE UNITED STATES

| *Legume* | *Value of U. S. Crop* |
|---|---|
| Alfalfa | $ 416,178,534 |
| Clover in timothy and clover mixed (estimated) | 200,000,000 |
| Clover alone | 100,249,755 |
| Peanuts | 62,751,701 |
| Dry edible beans | 61,759,225 |
| Clover and alfalfa seed | 55,416,726 |
| Velvet beans (estimated) | 50,000,000 |
| Annual legumes cut for hay | 47,094,363 |
| Cannery beans | 30,000,000 |
| Cannery peas | 23,000,000 |
| Dry peas | 20,790,541 |
| Soybeans | 4,450,000 |
| Other beans | 824,000 |
| Horse beans | 124,235 |
| Total | $1,072,639,080 |

## CHAPTER II

## *CLASSIFICATION AND DESCRIPTION OF COMMON BEANS*

No other kind of bean grown in America compares in importance with the common or genus Phaseolus, otherwise known as the kidney or haricot bean, to which nearly all of the cultivated field and garden sorts belong. Excepting soybeans and cowpeas, practically all of the commercial bean production of the United States is of this type. Several hundred varieties are listed by seedsmen, but many of these are synonymous.

Bailey [1] describes Phaseolus as follows: "A wide range of annuals and perennials, mostly in warm and tropical countries, usually herbs, but a few woody at base, grown somewhat for ornament but mostly for the edible seeds and pods; the known species are probably 150-200, when the extensive synonomy shall have been reduced.— Mostly twining, some forms erect: leaves pinnately 3-foliolate but sometimes reduced to 1 leaflet, stipulate and stipellate, the stipules persistent, leaflets entire; flowers few to many, racemose or fascicled on axillary peduncles, white, yellow, red, purple, papilionaceous, closely subtended by 2 bracts like an outer calyx which are sometimes deciduous; lobes of calyx equaling or exceeding its tube; keel coiled, being the distinctive mark of the genus: stamens 9 and 1; style bearded longitudi-

[1] Bailey, L. H. "Manual of Cultivated Plants," pp. 395-397. The Macmillan Company (1924).

nally: fruit compressed or with convex sides, several- to many-seeded, dehiscent; germination hypogeal or epigeal."

The commonly known species of Phaseolus grown extensively in America in order of importance are the kidney bean, *P. vulgaris,* large or true lima, *P. limensis,* small or Sieva lima, *P. lunatus,* tepary, *P. acutifolius,* and the runner or multiflora beans, *P. coccineus.* The Metcalfe bean, *P. Metcalfei,* and five species of oriental beans, namely, the adzuki, mung, urd, rice and moth, find limited use in the more arid regions of the South but are relatively unimportant commercially. Bailey in the Manual, gives the following taxonomic key to the species of Phaseolus cultivated in this country:

A. Color of flowers white, cream-colored, violet or red.
  B. Leaflets retuse or at least obtuse: plant with deep fleshy perennial root: flowers reddish-purple ..... 1. *P. Metcalfei*
  BB. Leaflets acute or pointed: annual or grown as annuals.
    C. Seeds (beans) on the small oblong or globular order, usually ⅝ inch or less long, not broad or prominently flattened.
      D. Calyx-bracts small and inconspicuous, much shorter than calyx itself. 2. *P. acutifolius*
      DD. Calyx-bracts broad and prominent, ovate, nearly equaling or exceeding calyx. 3. *P. vulgaris*
    CC. Seeds on the large broad order, usually nearly or quite as wide as long, often very flat.
      D. Flowers large and showy, mostly more than ½ inch long, white or scarlet. 4. *P. coccineus*
      DD. Flowers small, ⅜ inch or less long, white or cream-color.
        E. Calyx-bracts oval, strong-veined: pod thin-edged with sharp long beak. 5. *P. lunatus*

EE. Calyx-bracts linear, not strongly veined: pod thick-edged, large, with blunt or short tip.....6. *P. limensis*

AA. Color of flowers clear yellow: oriental beans.

B. Leaflets entire, or sometimes broadly 2- or 3-lobed.

C. Plant and pods very hairy or even shaggy: seeds usually dull.

D. Seeds (beans) oblong, blackish, with concave hilum or scar: pod long-hairy. 7. *P. Mungo*

DD. Seeds nearly or quite globular, green, brown, yellow, rarely blackish, the hilum not concave: pod short-hairy.....8. *P. aureus*

CC. Plant and pods glabrous or only thinly hairy: seeds glossy.

D. Pods constricted between seeds: hilum or scar not concave.....9. *P. angularis*

DD. Pods continuous: hilum concave 10. *P. calcaratus*

BB. Leaflets parted to base into 3-5 narrow divisions 11. *P. aconitifolius*

### KIDNEY BEAN, *P. vulgaris, L.*

The common field and garden beans grown in the United States may be classified according to habit of growth as bush or pole; according to condition for use as food as green-shell, snap- or "string"-beans, or dry-shell; according to color of the immature pod as green-pod or wax; and as field or garden. Naturally, there is much over-lapping of varieties from one classification to another. Most of the dry-shell crop of the country is of the bush type and of green-podded varieties. Snap beans are mainly of the green- and wax-podded sorts, the larger part being of the bush type. Green-shell beans are most commonly of the larger seeded types of either wax- or green-podded varieties. These are both bush and pole in habit of growth. The author suggests the following outline classification for field and garden beans of this

species, this being a modification of that proposed by Corbett.[1]

- Field
  - bush
    - pea (white or colored)
    - medium (white or colored)
    - marrow (white or colored)
    - kidney (white or colored)
  - pole
    - medium (white or colored)
    - kidney (white or colored)
- Garden
  - bush—kidney
    - wax
    - green-pod
  - pole—kidney
    - wax
    - green-pod

One of the most distinct differences between varieties of common field beans is that of size and shape of seed. For example, market reports usually quote prices on pea, medium, marrow and kidney beans. Jarvis [2] quotes the following key prepared by J. W. Gilmore descriptive of these four types:

Seed 1.5 cm. or more in length, more or less reniform, ratio—length, width, thickness—1 — .4869 — .3731.....*Kidney*
Seed between 1 and 1.5 cm. in length, thickness exceeding half the length. 1 — .6537 — .6029.....*Marrow*
Seed 1 to 1.2 cm. in length. Thickness less than half the length. 1 — .678 — .4975.....*Medium*
Seed 8 cm. or less in length, not uniform. 1 — .7467 — .6096 .....*Pea*

The kidney bean is an annual with more or less pubescent leaves, dwarf to tall-twining: leaflets broad ovate, 4 to 6 inches long and entire: flowers few at or near the apex of peduncles shorter than the leaves, white,

[1] Corbett, L. C. "Beans." Farmers' Bull. 289, p. 8 (1907).
[2] Jarvis, C. D. "American Varieties of Beans." Cornell Univ. Exp. Sta. Bull. 260, p. 165 (1908).

yellow or violet-purple in color, ½ to ¾ inch long; pods slender with convex sides, straight or slightly curved, 4 to 8 inches long with prominent beak; seeds globular to oblong, mostly not exceeding ⅝ inch in length, usually less and white, brown, red, blue-black or speckled in color. Germination is epigeal. The species is now thought to be native to South America from whence it was brought to the United States by the very early Spanish colonists. It now constitutes the principal bean of commerce, most of the crop of dry beans being limited to the north temperate states where the bean weevil, *Bruchus obtectus*, is not a limiting factor as it is in the South. Although snap and green-shell beans are grown in gardens throughout the more humid regions of the country, these are produced intensively as a truck crop in certain of the South Atlantic states and as a market-garden crop near the larger cities of the coastal states.

### LIMA BEANS

The true large-seeded lima is *P. limensis*, Macf. *P. lunatus*, L., is the sieva or small-seeded lima. By many writers the species *lunatus* has been used to designate both large- and small-seeded types, the variety name *macrocarpus, e.g. P. lunatus macrocarpus*, representing the large-seeded form. In the South, lima beans are commonly termed "butter" beans, which in the North applies to wax-podded string beans. The name lima apparently originated from the supposition that this species was first discovered in the locality of Lima, Peru. Lima beans are said to have been grown in Europe for more than three hundred years but are now cultivated more extensively in the United States than in any other country.

Although rather common in gardens throughout the states, most of the commercial crop of dry-shell beans is produced in Ventura County, California.

As indicated above, lima beans are of two rather distinct types, *P. limensis,* the large-seeded, and *P. lunatus,* the small-seeded. These species occur in both dwarf and pole varieties. The large-seeded lima may be divided into two classes, one including the flat-seeded varieties, the other the fat-seeded ones often spoken of as the "potato" limas. All beans of this species are epigeal in germination (the cotyledons appearing above ground). A useful character by which the species can more readily be identified is the presence of lines radiating from the seed scar or hilum to the dorsal suture of the seed. Bailey[1] includes the following in his description of the two principal types: *P. lunatus,* L. Sieva, Civet, Carolina, Sewee Bean. Slender, lightly pubescent or glabrate annual, with thin leaves: leaflets not very large, broad-ovate, 2-3½ inches long, entire, sharp-pointed, thin in texture: pods 2-3½ inches long, flat, about ¾ inch broad, thin edged, papery in texture and slightly pubescent, the beak very sharp; seeds flat and thin, about ½ inch long, white, brown, red or speckled. *P. limensis,* Macf. Lima Bean. Perennial but grown as annual, a much stouter, stronger, higher climbing, later flowering plant than *P. lunatus,* pubescent, with thick heavy leaves: leaflets long-angular-ovate, 3-5 inches long, long-pointed but not sharp, thick in texture: pod large, thick and heavy, 3-5 inches long and often 1 inch broad, margins thick and sometimes double-ridged, the beak short, stout and blunt; seeds larger than *P. lunatus,* plump, white.

[1]"Manual of Cultivated Plants," p. 396.

With the recent development of the large thick-seeded potato lima as a popular green-shell bean, it may be appropriate to recognize this as a distinct botanical variety. Dimon [1] proposes the name *P. lunatus turgidus* for the potato lima as correlevant to the other two more common botanical varieties. He distinguishes it from the large-seeded type by saying: "This type differs from the large flat lima in that it has narrower, longer pointed and duller green leaflets; the pods are shorter, thicker and straighter; and the green-shell and dry beans are smaller, more swollen or turgid and sub-circular in outline." The more obvious differences between these three classes of limas are illustrated in Figs. 33, 34 and 35.

### MULTIFLORA BEAN, *P. coccineus, L.* (*P. multiflorus*, Willd.)

This species is best known for the scarlet blossoms borne profusely on the variety Scarlet Runner which is used mostly as an ornamental in this country. It is much grown in England and some other parts of Europe, where it is utilized as a string-bean, as a green-shell bean, and in the dry state. The pod is somewhat fibrous and is prepared for cooking by being sliced diagonally. In the dry state the skins, being tough, are commonly removed before the beans are served. The so-called Oregon lima and the Aztec bean are of this species. Most varieties do not thrive in the hot dry summers characteristic of a large part of the United States. Although known generally as the Scarlet Runner or flowering bean, there are several varieties with white blossoms, chief among

[1] Dimon, C. E. "A Study of the Lima Bean." Cornell Univ. unpublished thesis (1914).

which is the variety White Dutch Runner. These latter are occasionally used in some of the southern states as green-shell beans for food. The species originated in South America, and occurs in both climbing and bush forms.

Bailey[1] describes it in part as follows: Perennial but grown as an annual: leaflets broadly rhombic-ovate, 3-5 inches long, entire: flowers several to many, mostly ¾-1 inch long, scarlet or white: pod 4-12 inches and more long, plump, lightly pubescent or glabrate, beak rather stout; seeds broad-oblong, ¾-1 inch long and two-thirds as broad, not tapering at ends, convex-flattened, nearly black with red markings; germination hypogeal.

METCALF BEAN, *P. Metcalfei,* Wooten & Standley (*P. rretusus, Benth.*)

Among the less important species is the Metcalfe bean recently introduced as a forage plant into the more arid regions of the Southwest by J. K. Metcalfe. It is discussed by Bailey [2] as having roots very large and fleshy, running deep into the ground; stem roughish; leaflets rhombic to oblong, mostly obtuse and often retuse, rough on both sides, with prominent veinlets, especially beneath; leaves thick and heavy and adapted to dry hot climates; flowers reddish purple; pods flat, short, broadly oblong, somewhat curved; seeds circular, compressed, ⅝ inch across, brown-black; stems trailing 8-10 feet or more long on mountains, where it is a favorite food for deer. It is grown mostly in New Mexico, Arizona and Mexico, but it is not promising in Arizona at elevations less than 4,000 feet.

[1] "Manual of Cultivated Plants," p. 396.
[2] Bailey, L. H. Standard Cycl. Hort., Vol. V., p. 2575 (1916).

TEPARY BEAN, *P. acutifolius,* Gray, var. *latifolius,* Freem.

The word Tepary, of Spanish origin, denotes a type of bean which apparently originated among the Mexican Indians and which has been recorded in the very earliest records of the western hemisphere. It is distinctly drought resistant and well adapted to the hot, arid climates of southern Arizona and Mexico. Freeman [1] distinguishes the Tepary from the kidney and lima bean in several characters. The seeds are smaller, averaging about .15 grams, while kidney beans average .23 grams and the limas .50 grams or more. The markings or flecks on the seed, when present, are much finer and the seed-coat lacks the characteristic glossiness of the kidney bean. The leaflets are not only much smaller but also narrower. A further difference of value in identifying the seedlings is the truncate instead of the cordate base of the first true leaves as in the kidney and lima and the very much shorter petioles. The plant is bushy on poor soil but twining several feet long on good land. The pods are 2-3 inches long, about ⅓ inch broad, compressed, nearly straight, finely pubescent and with sharp beak. The seed is roundish to oblong, ¼ to ⅜ inch long, convex or somewhat flattened, white, yellow, brown, black, and frequently with various shades of flecking.

The Tepary is grown by the Indians and Spanish settlers throughout southern Arizona and northern Sonora, Mexico. In several tests at substations in southern Arizona, it has outyielded the "frijoles" or common kidney species, probably because of its drought resistance. Teparies absorb water and germinate more readily than

[1] Freeman, G. F. "Southwestern Beans and Teparies." Ariz. Agr. Exp. Sta. Bull. 68 (1912).

common beans. However, it is doubtful whether it will become popular in American markets because of its somewhat inferior eating quality. Further discussion of the Tepary will be found in Chapter XVII on dry-land production.

### ORIENTAL SPECIES

Prior to the discovery of America, many species of Phaseolus were of considerable importance as food in Asiatic countries, which have since been more or less superseded by the kidney and the lima. Five of the more important oriental species have been introduced into the United States for trial primarily as forage and green-manure plants. These are the adzuki, *P. angularis,* Wight., the rice, *P. calcaratus,* Roxb., the mung, *P. aureus,* Roxb., the urd, *P. Mungo,* L., and the moth bean, *P. aconitifolius,* Jacq. Piper and Morse[1] have arranged the following key by which these five species can be distinguished:

Leaflets parted into 3 narrow lobes.....*Moth.*
Leaflets entire or occasionally 2- or 3-lobed.
  Plants and pods very hairy; seeds mostly dull.
    Pods with short hairs; seeds globose or subglobose, green, rarely brown, blackish or yellow, the testa marked with fine crenulate lines; hilum not concave.....*Mung.*
    Pods with long hairs; seeds oblong, blackish, the testa not crenulate striate; hilum concave .....*Urd*
  Plants smooth or little hairy; seeds smooth and shiny.

[1]Piper, C. V., and Morse, W. J. "Five Oriental Species of Beans." U. S. Dept. Agr. Bull. 119, p. 1 (1914).

Pods constricted between the seeds; hilum not concave ..... *Adzuki*
Pods not constricted between the seeds; hilum concave ..... *Rice*

These authors point out the following characters common to all five species: "Plants annual; stipules with a basal appendage; flowers yellow; keel spirally coiled, bearing on one side a hornlike appendage; style hairy, prolonged into a narrow appendage beyond the stigma; stigma lateral, subterminal; pods linear, subterete, sometimes torulose; seeds globose to oblong; hilum narrow, linear." At home, the adzuki is cultivated in Japan, Manchuria, China and Korea, the rice in China, India, Japan and the Philippines, the mung in all parts of Asia where it will mature, and the urd and moth in India. Test results in the United States so far do not indicate that any of these can compete profitably with either the cowpea or the common bean for forage, green-manure or food purposes.

## CHAPTER III

### *TYPES AND VARIETIES*

As early as 1900, more than 800 real or nominal varieties of bush and pole beans were catalogued by American seedsmen. Obviously many of these were sufficiently alike to be considered synonyms. It is equally obvious that this is a far greater number than is needed to fulfill the demands for dry-shell, snap, green-shell and canning purposes even under the wide range of climatic influences and market demands throughout the United States. According to Jarvis,[1] "A variety, in the horticultural sense, may be said to consist of those plants of a species which have been so altered by environment, selection, crossing, or other influences, that they have attained distinct and valuable characters." After a careful study and test of the varieties listed by some 250 seedsmen, this author classified and described 182 supposedly distinct varieties of green-podded, wax-podded and lima beans, listing synonyms for each. The number of varieties described in each class were dwarf green-podded 76, dwarf wax-podded 41, climbing green-podded 25, climbing wax-podded 10, dwarf lima 10, and pole lima 20. All of the important field or dry-shell varieties grown at that time were included in the dwarf green-podded class.

[1]Jarvis, C. D. "American Varieties of Beans." Cornell Univ. Agr. Exp. Sta. Bull. 260 (1908).

Information as to the method by which most standard bean varieties originated is not available. The earliest forms have continued to vary in plant and seed characters under both natural and artificial influences. Since bean blossoms are so constructed as to allow very little if any cross-pollination by wind, natural hybridization is almost a negligible factor. Crossing under field conditions is to a small extent affected by bumbebees. Segregation of distinct characters occurs in the more hybrid seed-stocks. Chance variations or "mutants" occur in beans as in all economic plants. Such variations as are caused by the above agencies have through selection and continuous propagation given rise to many varieties. A few valuable varieties have been originated by artificial hybridization to combine desirable characters such as high yield, disease-resistance, quality, and attractiveness. Many so-called varieties have been listed which in reality are synonyms resulting from the application of new, highly descriptive, or improper names. As an example of this, Jarvis[1] found the variety Red Valentine catalogued under sixty-seven different names. The various types and varieties of commercial importance within the species *Phaseolus vulgaris* may be classified according to habit of growth as bush or pole; according to condition of seed as harvested for food, as dry-shell, green-shell, or snap; according to shape of seed as pea, medium, marrow, or kidney; according to color of pod, as wax-podded or green-podded; and according to color of seed, as white, mottled, or colored. Reference to various methods of variety classification has been made in Chapter II. Although pole varieties have apparently been under cultivation much longer than bush varieties, the latter are

[1]Cornell Univ. Agr. Exp. Sta. Bull. 260, p. 157 (1908).

now more extensively grown, especially in regions where dry-shell beans are important and where the growing season is limited by killing frosts. Dry-shell beans far outrank the other forms in commerce, although snap-beans or "string" beans are an important truck crop in the South and East and are now canned extensively in the important canning-crop states. Owing to the hand labor involved in removing green beans from the pods, green-shell beans are not very important commercially. Referring again to Gilmore's classification according to shape and size of seed (Chapter II), varieties of the pea bean type outrank the others in commercial production. About 90 per cent of the Michigan crop is of this type, while 40 to 50 per cent of the New York crop is pea beans. Pea beans rank second only to limas in California. Most varieties of snap-beans are of the kidney type, while the Pinto variety of Colorado and the California Pinks grown in California are of the medium type of seed.

### DRY-SHELL OR FIELD BEAN VARIETIES

Field bean varieties are not botanically distinct from those used for other purposes. Probably all varieties commonly grown as field beans are of the dwarf green-podded type. To be well adapted for this purpose, a variety must first of all be dwarf, productive, hardy, disease-resistant, and sufficiently short seasoned to mature between killing frost dates. Furthermore, it must possess a seed color and a quality suited to the trade. Other desirable characters in a dry-shell bean are capacity to hold the pods off the ground sufficiently to prevent weathering, uniformity of ripening, non-shattering habit of the pods at maturity, and capacity of the seed to resist

splitting in the threshing process. Because of these requirements, relatively few varieties are now under cultivation as dry-shell beans. The number which is well known to the trade probably does not exceed fifty.

*Regional production of varieties*

An estimate of the relative importance of the leading types and varieties of field beans in the United States is shown in Table II.

From Table II it is apparent that the prevailing types produced in the northern and more humid regions are white in color, while those mainly grown in the semi-arid and warmer sections are largely colored or mottled. Most dry-land varieties are smaller and flatter seeded than those grown under the opposite conditions. Originally, the only variety grown for the trade was the small white pea bean first used by the Indians in New York. This is still the leading variety of commerce and is grown extensively in the states of Michigan, New York, Wisconsin, California, Idaho, Utah, Oregon, Washington, Maine and Vermont. It is the type mainly grown in Japan, and the countries of northern and central Europe. The principal varieties of field or dry-shell beans now grown in the respective leading bean producing states are for Michigan: Michigan Pea, Early Wonder, Michigan Robust, Vermont Pea, Red Kidney, and Brown Swedish; California: Lewis Lima, Daily Lima, Henderson Bush Lima, California Pink, Lady Washington, Blackeye (a small, blackeyed, white variety of cowpea), Small White, Blue-Pod, Cranberry, Bayo, Red Mexican, and Red Kidney; New York: Michigan Robust Pea, Navy Pea, Blue-Pod Medium, York State Medium, Red Kidney, Wells Red Kidney, Improved Yelloweye,

## TABLE II

ESTIMATED PERCENTAGE OF TOTAL PRODUCTION OF BEAN VARIETIES IN 8 LEADING STATES—AVERAGE 1920-1922 INCLUSIVE.

(Adapted from U. S. Dept. Agr. Weather, Crops & Markets Vol. 3, No. 24, June 1923.)

| Varieties | New York | Michigan | Wisconsin | Colorado | New Mexico | Arizona | Idaho | California | Total, 8 States |
|---|---|---|---|---|---|---|---|---|---|
| Small and Medium White | 33 | 93 | 86 | 4 | .. | .. | 77 | 9 | 38 |
| Large White | 13 | (a) | 8 | .. | .. | .. | (a) | 3 | 3 |
| Yellow Eye | 15 | .. | .. | .. | .. | .. | .. | .. | 2 |
| White Kidney | 8 | .. | .. | .. | .. | .. | .. | .. | 1 |
| Red Kidney | 25 | 6 | .. | .. | .. | .. | .. | 2 | 4 |
| Cranberry | .. | .. | .. | .. | .. | .. | .. | 1 | .. |
| Red Mexican | .. | .. | .. | .. | .. | .. | .. | 4 | 1 |
| Pinto | .. | .. | .. | 83 | 94 | 1 | .. | .. | 22 |
| Bayo | .. | .. | .. | .. | 2 | .. | .. | 1 | .. |
| Pinks | .. | .. | .. | .. | 2 | 79 | .. | 19 | 12 |
| Tepary | .. | .. | .. | 1 | .. | 4 | .. | .. | 1 |
| Lima | .. | .. | 1 | .. | .. | .. | .. | 48 | 6 |
| Blackeye | .. | .. | .. | .. | .. | .. | .. | 12 | 2 |
| Other (b) | 6 | 1 | 5 | 12 | 2 | 16 | 23 | 1 | 8 |

(a) Included with small and medium white.
(b) Includes varieties listed above when of small importance.

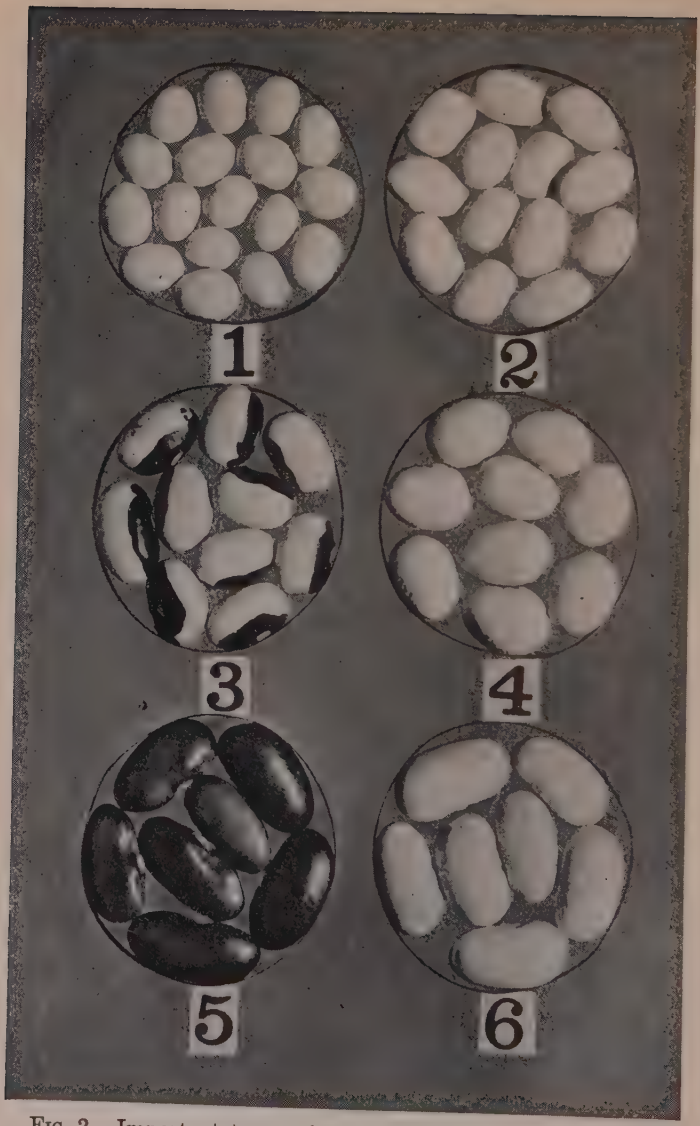


FIG. 2.—Important types of dry shell beans: (1) Pea, (2) Medium, (3) Yelloweye, (4) White Marrow, (5) Red Kidney, (6) White Kidney.

White Marrow, Nova Scotia Marrow, Perry Marrow and White Kidney; Colorado: Pinto, and White Pea; Idaho: Small white varieties; New Mexico: Pinto, Ancient Yellow, and Tepary; Arizona: Pink and Tepary; Montana; Great Northern.

*Regional adaptation*

The factors most influential in determining the type or variety for production in a given region are seasonal rainfall, cropping system, length of growing season, prevalence of bean diseases and insects, and market preferences. Whereas a moderate rainfall during the early growing season is desirable to promote growth, white-seeded varieties weather or discolor worse than colored ones in regions of high rainfall at harvest time. Red Kidney is preferred to white varieties in the regions of highest rainfall in western New York and in Michigan. Early varieties such as Michigan Pea, Early Wonder and Blue Pod Medium fit well in the rotation with winter wheat since they can be matured and removed from the land in time for autumn seeding of wheat. Since the anthracnose disease is most prevalent in humid regions, only anthracnose-resistant strains and varieties should be grown under these conditions. Inasmuch as the harvested crop is cleaned and marketed almost entirely through local dealers maintaining elevator equipment, the choice of type and variety should be governed largely by the advice of the local dealer. It is generally conceded that the larger seeded varieties, such as the kidneys, require somewhat heavier more fertile soils than small seeded varieties. Hendry [1] has classified the

[1] Hendry, G. W. "Bean Culture in California." Calif. Agr. Exp. Sta. Bull. 294, p. 40 (1921).

common bean varieties of California according to their tolerance of alkali in the soil as follows:

*Group* 1—Most tolerant:

Blackeye Horse Bean Garbanzo

*Group* 2—Moderately tolerant:

Lima Tepary

*Group* 3—Least tolerant:

| | |
|---|---|
| Cranberry | Lady Washington |
| Blue Pod | Pink |
| Small White | Red Mexican |
| Red Kidney | Bayo |

The author comments on the significance of the fact that all the varieties in groups 1 and 2 represent different botanical species from those in group 3.

Most varieties of the marrow and yelloweye types mature nearly as early as pea beans. White Marrows, because of the large uniform-sized white seed, usually command a good price. Yelloweyes do not sell as well, but are fairly reliable in yield. The variety is hardy, disease-resistant and because the plant holds its pods off the ground well is not very subject to weathering. Most pea bean varieties can be safely grown where the period between killing frosts averages 120 days, whereas it is not safe to grow White Kidney in a growing season of less than 140 days. A brief description and reference to factors related to regional distribution of the principal field bean varieties follows.

*Varietal description*

In describing the leading commercial varieties, only such characters are noted as are of value to the grower and the student in the identification of type and in choosing a variety for production under specific or regional

conditions. The characters noted for each in order are habit of growth, size of plant, color of foliage, color of blossom, relative number of pods to the plant, principal regions of production, season of maturity, susceptibility or resistance to the common bean diseases, and market.

*Bayo* (Fig. 3). Plant medium, semi-trailing, spreading; foliage medium green; flowers white; seed tan; pods many. Produced in Lower Sacramento River Valley, Stockton Delta, and coastal regions of southern California, and in parts of Arizona and New Mexico. Medium to late maturity. Susceptible to red-spider injury. Marketed in mining districts of Pacific Coast and to supply the Mexican trade in Texas, Arizona and New Mexico.

*Blue Pod Medium.* Plant medium, semi-trailing, spreading; foliage medium green; flowers white; seed white; pods medium in number and with bluish flecking. Produced in drier wheat-growing districts of western New York, in the coastal regions of California and to a limited extent in other northern bean-growing states. Season early. Susceptible to all common bean diseases. Market general.

*Brown Swedish* (Fig. 3). Plant medium, dwarf, upright; foliage dark green; flowers white; seed light brown; pods medium in number. Produced on a small scale in Michigan. Season early. Susceptible to blight and anthracnose. Market limited on account of color.

*California Cream.* Synonym, Sulphur Pea Bean, Eureka. Plant medium, dwarf, upright; foliage dark green; flowers rose-lilac; seed greenish yellow; pods medium number. Produced in scattered areas and in gardens. Season early. Disease-resistant. Market limited on account of color.

*Cranberry.* Synonyms, Speckled Cranberry, Red Cranberry, London Horticultural Pole, Scipio Pole, Wren's Egg. Plant large, full trailing, spreading; foliage medium green; flowers white; seed white with red blotches; pods medium to many. Produced in lower Sacramento River Valley of California. Grown in a small way as a green-shell pole bean in the East. Season late. Sensitive to extreme heat. Cannot be grown in upland sections of California. Marketed almost entirely among foreign element of eastern mining districts.

*Great Northern* (Fig. 3). Plant medium, semi-trailing, spreading; foliage dark green; flowers white; seed white, large, flattened kidney shape; pods many. Produced mainly in the Yellowstone

Valley near Billings, Montana, where it is the principal variety. Season early. Very productive under irrigation in Montana. Apparently very disease-resistant. Marketed largely in the Middle West.

*Lady Washington.* Synonym, Large White. Plant medium, larger than Navy Pea, semi-trailing, spreading; foliage medium green; flowers white; seed white and larger and flatter than Navy Pea; pods many. Produced extensively in coast districts and at high elevations in California, also the principal variety in eastern Washington, Oregon and northern Idaho. Season very early. Susceptible to common bean diseases. Market general. Not adapted for canning.

*Michigan Robust.* Synonyms, New Robust, Improved Robust. Plant small, semi-trailing, spreading; foliage light green; flowers white; seed white, small; pods very numerous. Leaves more persistent than in Navy Pea. Produced extensively in western New York and in Michigan. Acreage increasing rapidly. Season medium to early, about five to seven days later than Navy Pea. Immune to mosaic, very resistant to anthracnose and blight. Market general.

*Navy Pea.* Synonyms, Boston Pea, Marrowfat Pea, Boston Navy, Prolific Tree, 1,000 to 1, Early Navy and many others. Plant small, semi-trailing, spreading; foliage light green; flowers white; seed white, very small; pods numerous. Produced extensively in all the leading northern bean states. Season very early. Susceptible to all the common bean diseases. Market general, used extensively for canning.

*Nova Scotia Marrow.* Plant medium, semi-trailing, moderately spreading; foliage medium green; flowers white; seed white, large and tumid; pods medium in number. Produced to a limited extent in the Maritime Provinces of Canada and in the Finger Lakes region of central New York. Season medium to early. Very susceptible to blight, moderately resistant to mosaic and anthracnose. Market general.

*Perry Marrow.* Plant medium to large, semi-trailing, spreading; foliage medium green; flowers white; seed white and similar to Nova Scotia Marrow; pods medium in number. Grown mainly in the Finger Lakes region of central New York. A new variety produced by crossing Wells' Red Kidney and White Marrow. Resistant to anthracnose and mosaic, susceptible to blight. Market general.

*Pink* (Fig. 3). Plant medium, semi-trailing, spreading; foliage medium green; flowers white; seed pink, medium size, somewhat flattened and square ended; pods medium to many. Produced

extensively throughout California, New Mexico, Arizona and Mexico, second only to the lima in California. Not grown in the South and East. Season early to medium. Fairly resistant to heat and to disease. Market general throughout the Southwest, especially among the Mexican population. Market increasing through the Middle West.

*Pinto* (Fig. 3). Synonym, Mexican Pinto, Rosillo. Plant medium in size, semi-trailing, spreading; foliage medium to dark green; flowers white; seed grayish streaked and blotched with greenish to pink colors, medium to large and somewhat flattened; pods medium to many. Produced extensively as the principal variety in Colorado and New Mexico, a few being grown in Arizona and Mexico. Season medium to late. Susceptible to bean rust. Market mainly throughout the middle western and southern states, many being exported from New Orleans.

*Red Kidney* (Fig. 2). Plant medium in size, dwarf, upright; foliage medium to dark green; flowers rose-lilac; seed large, flattened, pink when newly harvested, dark red when old; pods medium in number. Produced extensively in the Finger Lakes district of central New York and is second in importance in Michigan. Grown to a limited extent in the coastal regions and the internal valleys of northern California. Season medium early. Resistant to mosaic, susceptible to anthracnose and blight. Marketed largely in the West Indies and used for canning.

*Red Marrow.* Plant small, semi-trailing, moderately spreading; foliage medium green; flowers rose-lilac; seed red, darker colored, larger, and less flat than variety Pink; pods medium in number. Produced in scattered areas of New York and New England, less grown than formerly. Season early. Susceptible to blight and anthracnose but resistant to weathering. Market mainly in export trade to West Indies.

*Red Mexican.* Synonyms, California Red, Red Spanish. Plant medium in size, semi-trailing, spreading; foliage medium green; flowers white; seed red, medium to small and flattened; pods numerous. Produced mainly in the hotter drier inland valleys of California. Season early to medium. More resistant to powdery-mildew than the Pink, also fairly resistant to heat and drought. Market mainly in Cuba and Mexico.

*Tepary.* Plant large, semi-trailing, spreading; foliage medium green; flowers white or rose-lilac; seed smaller than Navy Pea, generally flattened, white, yellow, brown, bluish black, to deep violet, either self-colored or variously flecked, pods numerous. Produced mainly by the Indians and Spanish settlers in southern Arizona and northern Mexico. A few acres produced in Colorado

and the interior valleys of California. Season early to medium. Very resistant to heat and drought. Market limited, hence production not increasing at present time. Used mostly by Mexican population of the Southwest. Quality poor.

*Turtle Soup.* Synonyms, Black Turtle Soup, Black Spanish. Plant large, semi-trailing, spreading; foliage dark green with purple stems; flowers magenta; seed about the size of Navy Pea, black, flattened and square ended; pods numerous. Produced in scattering areas of New York and New England. Season medium to late. Very hardy and productive. Susceptible to blight. Market limited mainly to local trade and foreign population of large cities. Used mainly as dry-shell bean for soup-making.

*Wells Red Kidney.* Improved strain of Red Kidney resulting from selection of anthracnose-resistant plant in New York. Plant and seed characters identical with Red Kidney. Rapidly replacing the common strain in New York. Very resistant to anthracnose and mosaic but susceptible to blight. Market same as Red Kidney.

*White Imperial.* Plant large, vigorous, dwarf, erect; foliage dark green; flowers white; seed white, kidney-shaped, somewhat smaller and more rounded than White Kidney; pods few, long and straight. Production limited mainly to New York. Season somewhat later than White Kidney. Season late. Very resistant to anthracnose and mosaic. Somewhat subject to blight. Market mainly the Italian trade in larger cities. Price usually lower than White Kidney.

*White Kidney* (Fig. 2). Synonyms, Imperial Dwarf Kidney, Royal Dwarf, Royal Kidney. Plant large, dwarf, erect; foliage dark green, leaves larger, broader than Red Kidney; flowers white; seed white, large, kidney-shaped; pods few, long, flat, and straight. Produced mainly in New York in regions of long growing season. Season late, later than Red Kidney. Vigorous, productive and very high quality. Susceptible to common diseases except mosaic. Market same as White Imperial, but price usually much higher.

*White Marrow* (Fig. 2). Synonyms, Marrowfat, Great Western, Mountain, White Cranberry. Plant medium size, semi-trailing, spreading; foliage medium green; flowers white; seed white, tumid; pods medium in number. Grown mostly in Finger Lakes region of central New York. Season medium to early. Susceptible to most bean diseases except mosaic. Market general.

*Yelloweye* (Fig. 2). Synonyms, Improved Yelloweye, Yellow-eyed China. Plant medium in size, semi-trailing, spreading; foliage medium to light green; flowers white; seed slightly smaller

and less tumid than White Marrow, with clearly defined yellow blotch or eye around the seed scar; pods medium in number. Grown mainly in Finger Lakes region of central New York and in the New England states. Season medium to early. Very hardy, prolific and fairly disease-resistant. Marketed mainly in Boston, other New England markets and occasionally in the South.

*York State Medium* (Fig. 2). Synonyms, Burlingame, White Medium. Plant small, semi-trailing, spreading; foliage medium green; flowers white; seed white, somewhat larger and more flattened than Navy Pea; pods medium in number. Grown mostly in western New York in same regions as Navy Pea. Season early. Susceptible to all bean diseases. Market general.

*Comparative yields*

The productivity of a given variety varies in a given locality with such factors as strain of seed, weather, soil fertility, prevalence of disease, and date of first killing autumn frost. Therefore, in interpreting the results of a variety test comparing several types and varieties, the above factors must be given due consideration. Early fall frost, or wet weather at harvest time, may result in low yields of kidney varieties in a year when pea beans, because of their short growing season, produce a high average yield. On the contrary, kidney beans might outyield pea beans in the same region in a normal year. The summarized results of variety trials at the Cornell University Experiment Station,[1] during the years 1915 to 1922, inclusive, are given in Table III.

In commenting on the results the author states, "It cannot be concluded safely that, because the kidney varieties yielded highest over a period of seven years, this is the best type for Tompkins County. During this period, the kidney type yielded highest only twice, the marrow

[1]Hardenburg, E. V. "The Production and Marketing of Field Beans." Cornell Univ. Extension Bull. 98, p. 15 (1924).

TABLE III

COMPARATIVE YIELDS OF FIELD-BEAN TYPES, INCLUDING 39 VARIETIES, DURING THE PERIOD 1915 TO 1922,* AT ITHACA, NEW YORK.

| Type | Total Number of Varieties | Average Number of Varieties Tested Annually | Yield, in Bushels, to the Acre | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1915 | 1916 | 1918 | 1919 | 1920 | 1921 | 1922 | Average |
| Pea..... | 19 | 8 | 16.6 | 13.0 | 11.9 | 10.3 | 13.6 | 15.6 | 13.9 | 13.6 |
| Medium... | 3 | 2 | .... | .... | 5.3 | 27.1 | 13.3 | 17.7 | 14.6 | 15.6 |
| Marrow.... | 7 | 5 | 22.1 | 15.9 | 6.0 | 14.0 | 16.2 | 16.0 | 14.7 | 15.0 |
| Kidney.... | 10 | 4 | 22.0 | 17.0 | 4.7 | 26.0 | 14.2 | 29.9 | 14.1 | 18.3 |
| Averages and totals | 39 | 19 | 20.2 | 15.3 | 7.0 | 19.4 | 14.3 | 19.8 | 14.3 | 15.6 |

* Yields for 1917 were lost because of wet weather, and therefore are not included in this table.

type three times, the medium type once, and the pea type once. The growing seasons of 1916, 1919, and 1921 were drier than normal at Ithaca, while the rainfall of 1915, 1918, 1920 and 1922 was higher than normal. The average yields of all varieties for each of these two periods were 18.2 and 13.9 bushels an acre, respectively, an average difference of 4.3 bushels an acre in favor of the drier years. The low average yields for 1918 were due to a killing frost on September 11 of that year, whereas the average date of the first killing frost is October 10." As is evident in Table III, pea beans were the only ones which matured in time to escape serious damage.

Other variety trials are reported in California Experi-

FIG. 3.—Important varieties of dry-shell beans grown in the West, Mountain, and Pacific Coast States: (1) Brown Swedish, (2) Great Northern, (3) Bayo, (4) Blackeye, (5) Pink, (6) Pinto.

ment Station Bulletin 294, page 37; Ontario Department of Agriculture Bulletin 232, page 5; Minnesota Experiment Station Bulletin 46, page 355; Utah Experiment Station Circular 37, page 20; and West Virginia Experiment Station Circular 18, page 2, but the results are mainly of local significance and are not reported here.

*Proportion of beans to straw*

The proportion by weight of grain to straw in beans is somewhat higher than in the small grains. This varies considerably with the type and variety. Vining or trailing types may or may not yield a lower percentage of seed than dwarf types. Duplicate row samples of many varieties were tested at Cornell University in 1921 and 1922, the results being shown in Table IV.

TABLE IV

PERCENTAGE BY WEIGHT OF BEANS TO STRAW IN VARIETIES TESTED IN 1921 AND 1922. DEPARTMENT OF VEGETABLE GARDENING, CORNELL UNIVERSITY.

| Type | 1921 | | 1922 | | Per cent of Beans (Average 2 Years) |
|---|---|---|---|---|---|
| | Number of Varieties | Per cent of Beans by Weight | Number of Varieties | Per cent of Beans by Weight | |
| Pea..... | 9 | 54.3 | 10 | 42.6 | 48.5 |
| Medium..... | 2 | 52.6 | 2 | 41.8 | 47.2 |
| Marrow..... | 6 | 45.5 | 9 | 41.8 | 43.7 |
| Kidney..... | 7 | 36.9 | 6 | 40.9 | 38.9 |
| California small seeded varieties.... | .. | .... | 5 | 23.3 | .... |
| Totals and averages.... | 24 | 45.6 | 32 | 33.7 | 42.3 |

In arriving at these percentages, the unthreshed plants were first kiln dried. It will be noted that the pea and medium varieties yielded a grain to straw ratio of nearly 1 to 1, while the larger seeded varieties gave a somewhat lower yield of seed.

*Varieties for canning*

Immense quantities of dry-shell beans are preserved in tin seasoned with pork or with pork and tomato sauce. In this form the beans represent an important article of trade and commerce. A questionnaire letter sent to the leading packers of "pork and beans" throughout the United States revealed the fact that the common pea or navy type is mainly used for this purpose. Red Kidney variety is next in rank, followed by Mahogany Red Kidney and Yelloweye. The Mahogany Red Kidney is prized for its deep red color which maintains well in the canned product. Packers agree that high quality requires that the dry beans shall be baked before they become dry and tough, that they be choice hand picked grade, of uniform size and color, free from defects, and that they absorb moisture uniformly. Many varieties are unsuited because they split easily or disintegrate in the baking process. The industry is confined mainly to the northern bean-growing states of Michigan, New York, Wisconsin and New England.

*Foreign varieties*

Several varieties of field beans find their way into the United States from foreign shores, some of which compete with the native product. The variety of greatest prominence among these is the Kotenashi, produced in Japan and Korea. The name is descriptive of the variety

in that "tenashi" means stringless or vineless and "Ko" means small, hence small or bush beans. These are small and white, very similar to common pea beans and can, therefore, be sold on the same market. Chutenashi is a trade name designating the larger beans screened out of Kotenashi. Otenashi is a third variety imported from Japan. According to McCall,[1] varieties imported from Chile are principally Triguite, a large white pea bean, Caballerce, like White Kidney, and Triquito. Large colored seeded varieties such as Marauzuras, Chunagauzuras and Nagauzuras (Cranberry type) come in in small quantities from China and Manchuria to compete occasionally with similar varieties in California and the Southwest. South American beans from Argentina, Brazil, and Peru are mainly of the white pea and white kidney types. In recent years a few small shipments of pea and medium beans have been imported from Rumania. The principal variety from Mexico is the Garbanzo.

### SNAP-BEANS OR GARDEN VARIETIES

Snap-beans or "string"-beans are now grown in most rural and urban gardens. Their popularity is due largely to their ease of culture, their short season of growth, and the palatable, nutritious, easily prepared food which they furnish. They are not only eaten as a fresh vegetable, but large quantities are canned also. Snap-beans are classified as green-podded and wax-podded according to color of the pods at the edible stage. They may be classified also as bush and pole according to habit of growth.

[1]McCall, J. W. "Foreign Beans." The Bean and Pea Journal, Vol. 1, No. 6, p. 5, March, 1923.

Although the pole varieties have been in cultivation much longer, bush varieties, because of easier and more economical production, are now the more extensively produced. According to Irish,[1] "wax pods are, as a rule, less stringy than the green pods, but are also less hardy and somewhat more subject to disease . . ." At present the trend is toward increased production of green-podded varieties. This may be accounted for on two possible bases. The canners seem to favor the latter type and several improved strains of green-pods have been developed for stringlessness. N. B. Keeney of LeRoy, New York, one of the country's foremost bean-breeders, is credited with developing the variety Stringless Refugee Wax from Refugee Wax, and Rustless Golden Wax from Golden Wax. The latter improvement was toward resistance to the anthracnose or pod-spot disease. He also developed the variety Burpee's Stringless or Stringless Green-pod introduced by W. Atlee Burpee and Company in 1894, and now very generally catalogued by seedsmen.

Choice of varieties is not so much a problem of suiting the climatic influences as of fitting the variety to the purpose for which the crop is grown. Varieties for the garden may be either green-pod or wax-pod and should be chosen on the basis of season and quality rather than attractiveness alone. For canning, stringlessness, tenderness, color and uniformity in reaching the canning stage are all very important. The type demanded by the local canner must also be considered. To be a good variety for the truck-crop grower and the market-gardener, it must be, first of all, attractive, and earliness is important.

[1]Irish, H. C. "Garden Beans Cultivated as Esculents." Mo. Botanical Garden. Twelfth Annual Rept., p. 83 (1901).

*Varieties classified*

For convenience in selecting on the basis of type, some of the principal varieties are classified as follows:

Dwarf wax-podded: Davis White Wax, Round Yellow Six Weeks, Improved Golden Wax, Refugee Wax, Hodson Wax, Pencil Pod Black Wax, Wardwell Kidney Wax.

Dwarf green-podded: Bountiful, Refugee or 1,000 to 1, Burpee's Stringless Green-pod, Red Valentine, Goddard or Dwarf Horticultural (green-shell beans), Early Refugee, Black Valentine.

Climbing wax-podded: Golden Cluster, Kentucky Wonder Wax, Mont d'Or, Golden Carmine.

Climbing green-podded: Kentucky Wonder, London Horticultural (green-shell beans), Creaseback, Cut Short, Lazy Wife, Scotia.

For a detailed description of each of these varieties the reader is referred to Jarvis,[1] Irish,[2] and Tracy.[3]

*Markets and uses*

Both wax- and green-podded varieties are grown commonly in gardens. Most of these are of the dwarf type. It is difficult to say which varieties are most used, as these differ with each locality in each region. Davis White Wax, Round Yellow Six Weeks, Wardwell's Kidney Wax, and Golden Wax are among the most popular of the wax-podded sorts, while Bountiful, Refugee, Red Valentine, Black Valentine, and Stringless Green-pod are very common in home and market-gardens. Large city markets show rather definite preference for certain

[1]Cornell Univ. Agr. Exp. Sta. Bull. 260 (1908).

[2]Mo. Botanical Garden. Twelfth Annual Rept., p. 83 (1901).

[3]Tracy, W. W., Jr. "American Varieties of Garden Beans." U. S. Dept. Agr. Bur. Pl. Ind. Bull. 109 (1907).

varieties of snap-beans marketed as a fresh vegetable. Round-podded varieties such as Red Valentine, Black Valentine, and Round Podded Six Weeks are apparently more in demand in middle-western cities than are the flat-podded sorts. Flat-podded and green-podded varieties are said to be more popular in the East than in the West. Considered as a truck crop the most extensively marketed snap-bean varieties are probably Refugee, Red Valentine, Black Valentine, Stringless Green-pod, and Wardwell's Kidney Wax. For canning, in New York, where the industry is best developed, Refugee is distinctly the outstanding variety. Next to this in importance for canning are Refugee Wax, Hodson Wax, and Round Yellow Wax.

## CHAPTER IV

## *ECONOMICS OF PRODUCTION*

The common field, or dry-shell, bean, *Phaseolus vulgaris,* now occupies a very important place among the leading cash crops grown for food in the United States. Commercial production first began about 1839[1] in Orleans County, New York. A few quarts of seed of small white pea beans were brought by Stephen Coe to the town of Yates in this county from the lower Hudson River Valley of New York, where the crop had been grown and marketed in a small way for at least twenty years previous. Hand threshing and picking up to this time had been a laborious proposition. Western New York in 1839 was an important winter wheat-producing region, but frequently the stand was seriously injured by the Hessian fly, necessitating the substitution of some other short-season crop. Pea beans were, therefore, planted as a catch-crop following failures of winter wheat. During the Civil War, beans were found to be a very convenient, concentrated and highly nutritious food in supplementing the army ration. This helped to create a taste for beans which resulted in increased production during the post-war period. The extensive use of beans by the navy in later years has resulted in the application of the term "navy" beans to varieties of the small white pea and medium types. With the decreased production

[1] Stone, J. L. "Commercial Bean Growing in New York." Cornell Univ. Agr. Exp. Sta. Bull. 210 (1903).

of winter wheat and better control of the Hessian fly, beans are no longer much grown as a failure crop after wheat, but rather do they occupy an important place in the rotation of western New York, where they precede the wheat crop. Very little extra seed-bed preparation is necessary for wheat following beans, and the early varieties of beans can be harvested in time for autumn seeding of wheat. Furthermore, beans have a beneficial influence on crops which follow them in the rotation. Because the plant of the common field bean is small and has a rather sparse root system, it is not used as a legume for green-manure or soil-improving purposes in North America. It is essentially a food crop marketed in dry-shelled, canned, snap, and green-shell form.

Since earliest recorded history, various forms of beans have been used for food. Beans are today still more important as a food among southern European and southern Asiatic peoples than elsewhere in the world. Being best adapted to warm climates, the bean plant thrives vigorously in these regions, although the seed is usually smaller and flatter than in the cool temperate zones of Europe, Japan and the United States. The countries which lead in dry-bean production on the basis of acreage are in order—India, Japan, Italy, Rumania, Spain and United States. Total annual world acreage and production are approximately 25,000,000 acres and 225,000,000 bushels, respectively. The trend of acreage and production in the United States for the twelve-year period, 1914 to 1925, inclusive, is shown in Fig. 4.

### TREND OF PRODUCTION

The high acreage and production of 1917 and 1918 were largely the result of World War demands for food

FIG. 4.—Field bean acreage and production in the United States—1914-1925.

and the important place of beans in army and navy rations. Production declined rapidly in the three years, 1919, 1920 and 1921. This decline was due to several factors, most important among which were the overproduction during the war, and the accompanying agricultural panic of low farm prices in the years immediately following. The tariff act of 1913 levying a protective tax of only 25 cents a bushel against foreign beans failed to keep out the influx of Japanese pea beans. During these same years of depression, the New York and Michigan bean-growers also suffered the additional burden of exceedingly bad losses from bean diseases and unfavorable weather.

The rapid increase in production indicated in Fig. 4 for the years 1922 to 1925, inclusive, can be ascribed similarly to a combination of favorable circumstances. Bean reserves were at low ebb. Disease-resistant strains, such as Michigan Robust Pea, Wells Red Kidney, Nova Scotia and Perry Marrow, were available to the trade. The tariff act of 1922 providing a protective tax of $1.05 a bushel against foreign beans helped to limit bean importations. Dry-shell beans proved to be one of the few profitable cash crops produced on the farm during the agricultural depression of 1920 and 1921.

The relation between size of crop and farm price in the United States is indicated in Fig. 5. This relationship is apparently not very close, although tending to be positive. The reasons for this are probably several. Conditions were abnormal during the years of the World War, when both production and price were stimulated. The true relationship during the years 1914-1924 is somewhat submerged on account of the fluctuating price levels at this time. Beans may be classed as non-perish-

able, hence the acreage for a given year is influenced by the amount of crop held over by the elevators. Planting is governed somewhat on the advice of dealers, part of the crop being grown under verbal contract. The handling of beans from producer to consumer is a rather specialized business requiring close and direct relationship between grower and dealer.

### FACTORS AFFECTING REGIONAL IMPORTANCE

Extent or geography of dry-bean production varies with such factors as rainfall, distribution, temperature, cropping system, and marketing facilities. Successful harvesting and curing, especially of white varieties, requires little or no rainfall during this period. The factor of light rainfall in the autumn accounts in part for the importance of the industry in western New York, in the "Thumb" district of Michigan and in the important bean districts of the middle and far western states. Although beans yield well in warm climates, the severity of damage to the dry seed caused by the bean weevil under high temperatures, limits production of the common *P. vulgaris* to the cool temperate states of North America. Owing to the necessity of special labor-saving devices to clean and prepare the crop for market, the prospective grower must first assure himself that such facilities are available to his locality.

The acreage, production, and yield to the acre of dry beans in the six leading bean-producing states and in the United States, according to the census of 1920, are given in Table V.

These figures do not indicate present acreage and production, as both increased markedly in 1922 to 1925, inclusive.

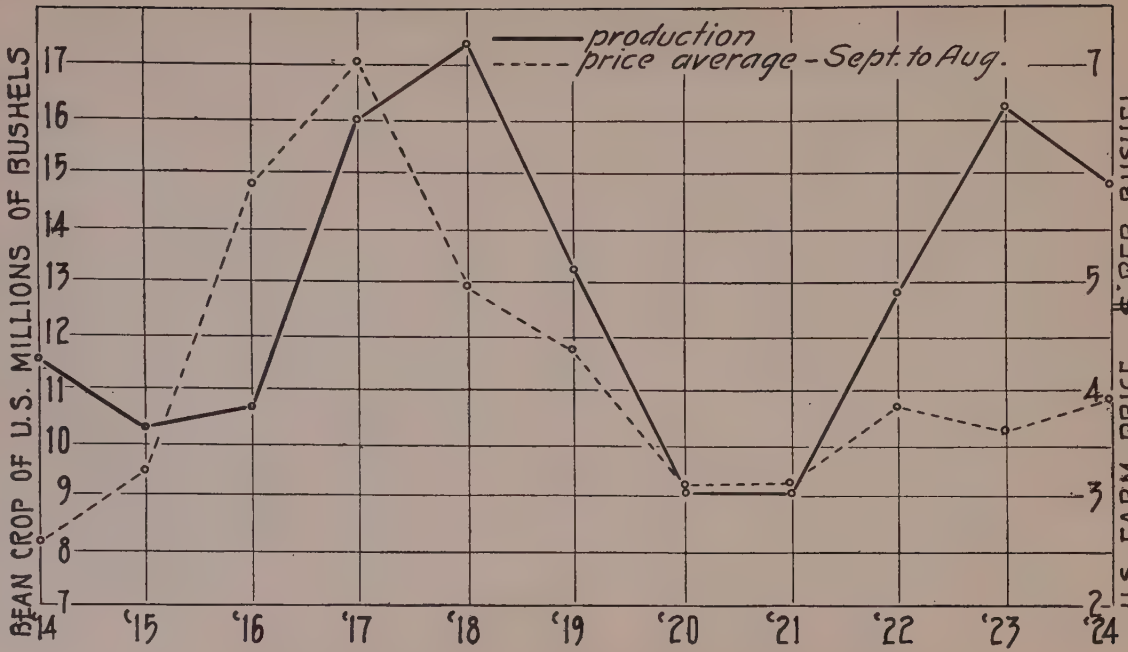


FIG. 5.—Size of the United States bean crop and price—1914-1924.

TABLE V

ACREAGE, PRODUCTION, AND YIELD TO THE ACRE BY STATES.
(United States Census, 1920.)

| State | Acreage | Production | Yield to the Acre (Bushels) |
|---|---|---|---|
| California | 471,674 | 6,553,000 | 13.9 |
| Michigan | 314,873 | 4,332,000 | 13.8 |
| New Mexico | 112,419 | 850,000 | 7.6 |
| Colorado | 66,236 | 428,000 | 6.5 |
| New York | 45,897 | 703,000 | 15.3 |
| Idaho | 33,941 | 344,000 | 10.1 |
| Other States | 116,642 | 869,000 | 7.5 |
| United States | 1,161,682 | 14,079,000 | 12.1 |

## COST OF PRODUCTION

The factors which most influence cost of production are labor in seed-bed preparation, seed, manure and fertilizer, weather at harvest time, and threshing. These factors naturally vary according to region and season. Compared to other common field crops, the cost of production of beans is considered to be about the same as for corn and wheat, higher than that of oats and hay, lower than that of potatoes and cabbage. Manure, fertilizer, seed, harvesting and curing, and threshing costs are higher in the East than in the West. In the former regions, more manure, fertilizer and seed are used, weather conditions require more time and labor to cure the crop and it is usually threshed at the barn. In the drier states of the West the labor cost of preparing the land and in either conserving fall and winter rains or providing it by irrigation are costly items not incurred in the East.

## TABLE VI

SUMMARY OF AVERAGE LABOR AND MATERIAL REQUIREMENTS TO THE ACRE OF FIELD BEANS ON 166 FARMS IN SEVEN STATES.

| Items | New York, Genesee Co. | Michigan, Tuscola Co. | Wisconsin, Columbia Co. | California (irrigated) Stanislaus Co. | Colorado (irrigated) Weld Co. | Colorado (non-irrigated) Weld Co. | New Mexico (non-irrigated) Mora and Torrence Cos. | California (non-irrigated) Ventura Co. | Idaho (non-irrigated) Latah Co. |
|---|---|---|---|---|---|---|---|---|---|
| No. of farms | 26 | 23 | 16 | 15 | 16 | 17 | 23 | 15 | 15 |
| Ave. yield in bushels | 10.9 | 5 | 7.3 | 20.7 | 25 | 6.8 | 4.1 | 26.5 | 9.1 |
| Man hours | 41.9 | 39.4 | 32.3 | 37.5 | 46.3 | 25.8 | 28.1 | 34.0 | 30.2 |
| Horse hours | 61.5 | 50.0 | 44.9 | 49.2 | 67.5 | 39.5 | 39.9 | 78.0 | 49.0 |
| Manure-tons | 3.57 | 1.33 | 3.42 | .42 | 2.96 | ..... | ..... | ..... | ..... |
| Fertilizer-pounds | 95 | 30 | 7 | ..... | ..... | ..... | ..... | ..... | ..... |
| Seed-pounds | 50 | 46 | 66 | 17 | 30 | 15 | 17 | 81 | 23 |
| Threshing fuel | 62[1] | 86[1] | 64[1] | ..... | 124[1] | 56[1] | ..... | ..... | .027[2] |
| Sacks-number | ..... | ..... | ..... | 13.8 | ..... | ..... | 2.5 | 15.9 | 3.7 |
| Percent of operating expense | 77 | 73 | 74 | 62 | 68 | 72 | 82 | 60 | 79 |

[1] Pounds of coal. [2] Cords of wood.

Washburn[1] determined the labor and material requirements of bean production on 166 farms in seven leading bean states in 1917. A summary of these items adapted from Washburn's study is given in Table VI.

The reason for the low requirements indicated for manure and fertilizer is that not all of the growers employed them. Hence the averages were determined by dividing the total acreage into the total quantities of each used. The percentage of total operating expense represented in these summary figures, *i.e.*, total cost less land rental, averages about 75 and ranges from 62 to 82 per cent in the respective regions.

Cost of production has increased decidedly in the last decade, as emphasized by reference to Table VII.

Cost of production is relatively high in wet years, when land preparation, weed control and extra hand labor to cure the harvested crop incur added labor expense. Cost of production a bushel and net returns are principally dependent on yields. Profits with beans must, therefore, vary principally with quality of seed, labor efficiency, seasonal weather, diseases, and cultural practices. Washburn[1] has shown that over 50 per cent of the cost of production is labor. Since much of the acreage of this crop is planted on sod land likely to involve difficult weed control and a poorly prepared seed-bed, management to conserve labor is recommended. Cost account studies with beans in Seneca County, New York, In 1914, showed that a saving of $6 an acre in labor cost of preparing land for wheat could be made by seeding winter wheat after beans.

[1]Washburn, R. S. "Labor and Material Requirements in the Production of Commercial Field Beans." Jour. of Farm Economics, Vol. III, No. 3, July (1921).

TABLE VII

COST OF PRODUCTION OF FIELD BEANS IN SEVERAL REGIONS OF THE UNITED STATES

| Region | Year | Number of Farms | Cost of Production to the Acre | Cost of Production a Bu. | Net Returns to the Acre | Net Returns to the Man Hour |
|---|---|---|---|---|---|---|
| Ontario Co., New York. | 1914 | 40 | $29.71 | $2.04 | $13.23 | $0.39 |
| Seneca Co., New York.. | 1914 | 18 | 34.00 | 1.83 | 18.75 | .53 |
| New Mexico..... | 1917 | (est'd) | 7.60[1] | .... | ..... | .... |
| Genesee Co., New York. | 1920 | (est'd) | 57.72 | 3.50 | ..... | .... |
| California[2] (dry-farming)..... | 1921 | (est'd) | 24.60 | 1.23 | 40.77 | .... |
| California (sub-irrigation)..... | 1921 | (est'd) | 22.05 | 1.10 | 43.32 | .... |
| California (surface irrigation) ..... | 1921 | (est'd) | 30.25 | 1.51 | 35.12 | .... |
| Genesee Co., New York. | 1923 | 14 | 41.19 | 2.46 | ..... | .61 |
| New York..... | 1914-1924 | 57 | 51.97 | .... | ..... | .13 |

[1] Labor cost only. From New Mex. Agr. Sta. Bull. 105, p. 33 (1917).

[2] Hendry, G. W. "Bean Culture in California." Calif. Agr. Exp. Sta. Bull. 294, p. 57 (1921).

## CHAPTER V

## *CLIMATIC AND SOIL RELATIONSHIPS*

BEANS are, by nature, a warm-season annual, sensitive to extremes of temperature, and requiring relatively high humidity. Profitable production of the more common field varieties is limited to the states bordering the Great Lakes, to certain favored areas of California and Colorado and to irrigated districts in Idaho, Arizona and Utah.

### CLIMATIC FACTORS

The optimum seasonal temperature for beans is about the same as that for corn and tomatoes. This is approximately 10° Fahrenheit higher than that for potatoes, cabbage, oats, peas, and wheat. Extremely high temperatures may interfere with the setting and filling of the seed-pods, while low temperatures are unfavorable to vegetative growth. The plant is especially susceptible to frost-injury, the late-planted crop in the Great Lakes states occasionally being injured or destroyed by early killing autumn frost.

Rudolfs [1] studied the influence of air temperatures on the growth-rate of *Phaseolus vulgaris* seedlings under greenhouse conditions by determining the number of days required for the seedlings to reach a length of 140

[1] Rudolfs, Willem. "Influence of Temperature and Initial Weight of Seeds upon the Growth-rate of *Phaseolus vulgaris* Seedlings." Jour. Agr. Res. 26: 537-539 (1923).

millimeters under various temperatures. His results are briefly summarized in Table VIII.

TABLE VIII

INFLUENCE OF AIR TEMPERATURE AND INITIAL WEIGHT OF SEED ON THE GROWTH-RATE IN *Phaseolus vulgaris* SEEDLINGS.

| Type of Seed | Temperature °C | Temperature °F | Number of Days to Reach 140 mm. Growth |
|---|---|---|---|
| Large and small | 10 | 50 | 9.8 |
| Large | 15 | 59 | 7.8 |
| Small | 15 | 59 | 8.8 |
| Large | 20 | 68 | 3.1 |
| Small | 20 | 68 | 8.5 |

Practically no growth was obtained from either large or small seed at 5° Centigrade. The author comments that weight of seed or amount of reserve food is the principal determiner of growth-rate, while temperature acts mainly as an accelerator.

Production of the common field bean is of small commercial importance south of Washington, D. C., and east of the Mississippi River, largely on account of the prevalence and injury of the bean weevil, *Bruchus obtectus*, under the high average temperatures of this region. High temperatures both during the growth period and during storage, favor weevil infestations.

In spite of the susceptibility to frost-injury, production areas are seldom limited by length of growing season. Most varieties of pea beans will mature in 100 to 110 days, while the latest varieties of the kidney type seldom require more than 125 days from planting to maturity.

In most of the commercial bean-growing areas, rain-

fall is not a limiting factor. Beans are very sensitive to both drought and extremes of moisture. This may be due party to the rather sparse and shallow root system of the plant. In years of abnormally high rainfall in New York and in Michigan the crop is subject to injury from the anthracnose disease and from water-logged soils. Low rainfall at harvest time is especially essential to provide against weathering of the seed and to proper curing of the harvested crop. Commercial areas of production in New York, Michigan and California are situated in regions of relatively low seasonal rainfall. Much of the crop in the West and Southwest is grown with the aid of irrigation water.

The water requirement of beans as determined by several investigators is reported by Lyon and Buckman.[1] It is shown to be lower than that of eleven other important field crops by two investigators, while a third reports it to be higher than that of most field crops except clover and peas.

Hendry[2] has well summarized the climatic requirements of beans in California as follows: "All of our varieties excepting the Horse bean thrive in the warm, humid coast climate of Southern California. All excepting the Lima, Tepary, and Blackeye do well in the cool, humid coast climate of Central California, but only the Tepary and Blackeye are able to produce satisfactorily in the hot, dry climate of the interior valley uplands." This author also gives the average mean relative humidity of a typical bean district during the growing season

[1]Lyon, T. L., and Buckman, H. O. "The Nature and Properties of Soils." The Macmillan Company, p. 189 (1922).

[2]Hendry, G. W. "Bean Culture in California." Calif. Agr. Exp. Sta. Bull. 294 (1921).

months of May, June, July and August as 85.2, as contrasted with that of a district in which the common bean cannot be grown successfully as 57.4.

### SOIL ADAPTATIONS

The often expressed notion that beans will grow well on infertile soils is erroneous. The idea probably originated from the fact that the crop in the past has been often relegated to soils thought too poor for other crops. By nature a sensitive plant, it has certain definite soil requirements. Neither extremely heavy mineral soils, such as adobes and clay loams, nor soils of organic origin, such as muck and peat, are well suited to bean production. The former are too much subject to puddling, while the latter are likely to produce not only a late maturing crop but one with an undue proportion of vine to seed. Medium loams of moderate fertility are recommended. Soils underlain with a shallow hard-pan subsoil do not permit development of the maximum root system. Neither extremely heavy nor extremely light soils are suited to maintain the uniform available moisture supply essential for the crop. Several years ago, Stone [1] conducted a series of coöperative variety tests on various types of soil in New York. Since these tests were on separate farms, sometimes at considerable distances apart, the comparisons of the effects of soil type on yield are somewhat empirical. However, his results in this regard are of some interest, as shown in Table IX.

In arbitrarily classifying the soils used in these variety tests, clays and clay loams were classed as heavy, while medium loams, sandy loams and gravelly loams were

[1]Stone, J. L. "Commercial Bean Growing in New York." Cornell Univ. Agr. Exp. Sta. Bull. 210 (1903).

TABLE IX.

RELATION OF SOIL TYPE TO YIELD OF BEAN VARIETIES IN CO-OPERATIVE VARIETY TESTS IN NEW YORK, 1900-1901.

| Variety | 1900 | | 1901 | |
|---|---|---|---|---|
| | Heavy Soils | Light Soils | Heavy Soils | Light Soils |
| | Bu. to the Acre. Ave. 7 Tests | Bu. to the Acre. Ave. 7 Tests | Bu. to the Acre. Ave. 5 Tests | Bu. to the Acre. Ave. 3 Tests |
| Marrow Pea..... | 14.45 | 15.19 | 20.95 | 27.03 |
| Day's Leafless Medium | 13.00 | 12.55 | 19.39 | 31.15 |
| Red Kidney..... | 8.83 | 11.25 | 18.62 | 22.90 |

classed as light soils. In spite of the fact that drought was generally prevalent in 1900, the author concluded that these tests presented much evidence in favor of the lighter soil types.

An important reason for the undesirability of heavy soils is their tendency to warm up and to dry out so slowly as to result frequently in rotting of the seed at planting time.

Soil temperature has been shown to be a factor of considerable importance. Reddick[1] studied the influence of three soil temperatures on rate of growth by using water baths to control soil temperatures under greenhouse conditions. His results are given in Table X.

Reddick's studies emphasize the importance of soil temperature approximating 90° Fahrenheit for maximum vegetative growth. Growers in New York frequently

[1]Reddick, Donald. "Effect of Soil Temperature on the Growth of Bean Plants and on their Susceptibility to a Root Parasite." Amer. Jour. Bot., Vol. 4, pp. 513-519 (1917).

TABLE X

RELATION OF SOIL TEMPERATURE TO RATE OF GROWTH IN BEANS.

| Temperature | | 12 Days After Seeding | 45 Days After Seeding |
|---|---|---|---|
| °C | °F | | |
| 34 | 93.2 | Developing first trifoliate leaves | Beginning to blossom |
| 22 | 71.6 | First pair true leaves only | Began blossoming 11 days later |
| 15 | 59.0 | Not entirely through soil surface | Plants dead or very weak |

experience serious losses from injury to the seedling plants caused by the bean maggot, *Phorbia fusciceps*, when the seed is planted in cold, wet, poorly prepared soil.

Soils for this crop should contain at least a moderate amount of the essential nutrients, nitrogen, phosphorus, and potassium. Of these, phosphorus is most likely to be deficient in the soils available. Soil fertility is not usually a limiting factor, as the bean crop probably draws relatively less heavily on the soil supply than most other field crops. It has only a moderate lime requirement as compared to other crops, but is not adapted to acid soils. The so-called "bean-belt" of western New York is confined largely to the limestone outcrop which extends through this region. Whereas artificial inoculation of either the seed or the soil with bean legume bacteria is recommended for regions in which beans have not been grown previously, almost no such inoculation has been practiced up to the present time. Experimental or test data to substantiate the recommendation are lacking.

## CHAPTER VI

## *ROTATION, FERTILIZING AND SEED-BED PREPARATION*

It has been shown that beans are especially sensitive to the influences of climate and of soil type. Somewhat in contrast, this crop is probably less influenced by the factors of rotation and fertilization than the average field crop. However, seed-bed preparation is of considerable import, as will be pointed out.

### ROTATION

In the newer bean-growing regions of the western states, beans have no fixed place in the cropping system. In California they frequently follow some other cultivated crop and occasionally follow beans. This is true also in Colorado and the Southwest. In many of the fruit regions of the West, beans are planted as a companion crop in young orchards. In the older bean-growing districts of the East, beans most commonly follow hay, although where corn and potatoes are major crops these are usually given the benefit of the sod residue and beans follow the latter. From the standpoint of crop yields, the ideal rotation is beans, wheat, clover. However, growers seldom find it economical to plow down clover sod after a one-year stand. As a result, the com-

mon rotation in western New York is beans, wheat, clover, timothy. Frequently the rotation is even longer, with potatoes or corn added after sod. Approximately 75 per cent of the bean acreage in New York is planted on sod. In the oldest bean-growing sections of western New York, beans fit well economically into the farming system. Bean land can be fitted for winter wheat with a minimum of labor by merely harrowing the bean stubble. Sheep-raising and the fattening of hothouse lambs over winter furnish a profitable means of disposing of bean straw and cull-beans returned from the local elevator. In common with other legumes, beans undoubtedly result beneficially to crops which follow in the rotation by virtue of the available nitrogen left in their decomposing root residue. However, definite data to substantiate this view are lacking. Where the crop has been grown frequently on the same soil, as in the older bean regions, there is danger of injury from such diseases as bacterial blight, and dry root-rot. The latter presents a rather serious problem in Wyoming County, New York, where growers find it necessary to practice a long rotation, and to avoid the use of infected manure from livestock fed diseased bean straw.

Late maturing varieties such as White Kidney are not well adapted to rotation with winter wheat. Most other varieties are, however, suited to this purpose. Beans should not be seeded after old weedy stands of hay, because the crop does not withstand weed competition well, and may be injured seriously by too harsh cultivation.

### FERTILIZING

The demands of the bean plant for nitrogen and min-

eral nutrients are relatively small. McCool and Millar[1] have shown that an acre yield of 25 bushels of beans contains 60 pounds of nitrogen, 18 pounds of phosphoric acid and 19.5 pounds of potash, while the corresponding acre yield of 2,000 pounds of straw contains 28, 6, and 38 pounds, respectively, of these elements. These totals are somewhat higher than those for many other common crops. However, fertilizer needs of the crop are not governed by such figures. Most of the nitrogen so accumulated is derived from the atmosphere, and potash is almost never a limiting factor in soils used for beans. The common practice in the East of planting the crop on sod land insures not only plenty of organic nitrogen, but a plentiful supply of available potash. As a crop grown primarily for seed production, phosphorus is the element most needed.

*Effects of different fertilizers*

A rather large supply of available nitrogen is used by the plant in maintaining its vigor and in developing its highly nitrogenous tissues. Excessive quantities supplied artificially, however, may cause the plant to develop vegetatively, or "run to vine" at the expense of seed, to mature late, and to ripen unevenly in the case of dry-shell beans. Phosphorus is considered essential to seed formation, and promotes earliness and uniformity of ripening. The principal source of phosphorus is acid phosphate, the latter carrying sufficient sulfur to aid in the synthesis of protein. Phosphorus is the essential element most commonly lacking in bean soils, and the element in

[1]McCool, M. M., and Millar, C. E. "Fertilizers, What They Are and How to Use Them." Mich. Special Bull. 133, p. 7 (1924).

commercial fertilizers which has given most profitable results. Although potassium is essential to growth and vigor in beans, it seldom needs to be supplied commercially. This is especially true when sod top-dressed with stable manure is plowed under in preparation for beans. Manure is so used by a large proportion of growers in New York, and although probably it would more often pay better applied to other crops in the rotation, its use frequently results in increased yields. Growers in Wyoming County, New York, where the dry root-rot disease is prevalent, employ it regularly to insure sufficient plant vigor to withstand the attacks of this disease. Manure is more commonly used by growers of marrow and kidney varieties than by growers of the small-seeded sorts. Very little manure is employed for beans outside of New York. When used, it should be applied in small amounts, in well-decomposed form, preferably in the fall. Spring applications are likely to be attended with increased losses from the bean maggot.

*Fertilizer practices*

Except in the older bean areas of New York and Michigan, the crop is fertilized very little or not at all. Most fertilizer tests have indicated that large applications do not result profitably. During the years 1899 and 1900, Stone[1] conducted coöperative fertilizer tests with field beans. The average yields for eleven such tests are summarized in Table XI.

The plots were one-tenth or one-twentieth acre in size and of either three or six rows. Apparently no duplicate plots were used. The results are interesting in that the response from phosphorus, whether used singly or in

[1]Cornell Univ. Agr. Exp. Sta. Bull. 210 (1903).

TABLE XI

Coöperative Fertilizer Tests in New York, 1899-1900.
(Average of 11 tests.)

| Fertilizer | N[1] | P[2] | K[3] | Check | N. P. | N. K. | P. K. | N. P. K. |
|---|---|---|---|---|---|---|---|---|
| Yield to the acre (bu.).. | 14.71 | 17.64 | 14.70 | 13.92 | 17.24 | 15.06 | 17.21 | 16.69 |

[1] N = Nitrogen. [2] P = Phosphorus. [3] K = Potassium.

combination with the other elements, was more significant than from either nitrogen or potash. Kinney[1] also demonstrated the importance of phosphatic fertilizer for beans in a test using twelve varieties of bush beans at the Rhode Island Station. The fertilizers were applied after the plants came up at the rate of 1,000 pounds to the acre on two-row plots each 40 feet long and 2 feet apart. The results are shown in Table XII.

TABLE XII

Fertilizer Test with 12 Varieties of Bush Beans at the Rhode Island Experiment Station, 1891.

| Fertilizer | Average Yield in Bushels |
|---|---|
| Dissolved bone black | 19.00 |
| Potassium sulfate | 16.53 |
| Ammonium sulfate | 12.54 |
| Sodium nitrate | 13.37 |
| Potassium chloride | 14.42 |
| Check (no fertilizer) | 11.97 |
| Average (12 varieties) | 14.62 |

The author points out that dissolved bone black, the least expensive fertilizer used, increased the yield 58.7

[1] Kinney, L. F. "Experiments with Fertilizers." R. I. Agr. Exp. Sta. 3rd Annual Rept., pp. 154-155 (1891).

per cent over the check. The increase from potassium sulfate was 38.1 per cent, while that from potassium chloride was only 20.4 per cent. Neither form of nitrogenous fertilizer proved profitable. A few years later, Wheeler[1] at the same station compared sodium and potassium salts in their effects on a crop of common pea beans. "Lime was slightly helpful to the beans when sodium and potassium were present in chlorides, but when carbonates were used, it seemed to be injurious. Common beans, therefore, thrive on a very acid soil. The average crop was nearly five times as great where the full rations of potassium salts were used as where the full rations of sodium salts were employed."

Recent plot tests by the author at the Cornell Station comparing the effects on yield of pea beans of varying amounts of acid phosphate, both with and without manure, have indicated (1) that larger amounts than 300 pounds to the acre of acid phosphate were unprofitable, and (2) that whereas stable manure used with 300 pounds of acid phosphate gave increased yields, the increase was not sufficient to return a net profit for the manure.

The analysis and quantity of fertilizer to be used in a particular instance should depend on the natural fertility of the soil, the type of beans grown, and the fertilizer practice with reference to other crops previously raised or to be grown on the same land. Where manure has been employed for the benefit of preceding crops, only acid phosphate will be needed ordinarily. If beans follow a cultivated crop on land which is cropped heavily, a complete fertilizer such as a 4-12-4 or its approximate is recommended. Although the 2-8-10 analysis is

[1]Wheeler, H. J. "Plant Peculiarities as Shown by the Influence of Sodium Salts." R. I. Exp. Sta. Bull. 104, p. 90 (1905).

still in common use by many growers in the East, the large amount of potash contained in it is apparently not warranted. Neither experiments nor experiences up to the present, have shown any justification for the utilization of larger amounts than 500 to 800 pounds to the acre. The actual amount will vary with conditions similar to those referred to under analysis. A crop survey of 323 bean farms in western New York in 1918 showed that whereas nearly 40 per cent of the growers used no fertilizer at all, the average acre application of the remaining 60 per cent was 205 pounds.

Bean fertilizer is usually applied just before or at the time of planting. A common practice is to drill the fertilizer with the grain drill, using all delivery hose except those seeding beans. It is not advisable to apply fertilizer in immediate contact with the seed, as the tender bean seedling is very susceptible to fertilizer injury. This is especially true when the larger applications are employed.

### SEED-BED PREPARATION

Either autumn or early-spring plowing is advisable with sod land. This is especially true of the heavier soils, as early plowing facilities decomposition of coarse organic material, earlier drying and warming of the seed-bed, and the elimination of injurious soil-inhabiting insects. Thorough preparation is important, as it obviates the necessity of much late-season cultivation which might injure the crop. The bean plant, being shallow rooted and easily broken over or pulled out, is not well adapted to withstand rough cultural treatment. Rolling, as a means of fitting bean land, both before and after planting, is beneficial as it smooths the surface soil, im-

proves the tilth, and firms the seed-bed, thereby promoting more rapid and even germination (Fig. 6).

Deep fall plowing is recommended in the unirrigated regions of California and the semi-arid West in order to

FIG. 6.—Land roller of much value in fitting bean land.

allow maximum absorption of autumn and winter rainfall and to reduce run-off and surface evaporation to a minimum. In the more arid regions, bean land is often irrigated immediately after plowing and fitting and before the crop is planted.

## CHAPTER VII

### *SEED*

The mature seed of the common bean, because of its large size, lends itself well to study of structure as representative of the type found in most legumes. A few hours soaking in water will cause it to enlarge by 50 to 100 per cent of its normal size. By reason of its capacity for water absorption, its physical and chemical qualities are very subject to change, with the result that it is by no means imperishable as a stored crop. Culinary quality, color, viability, and longevity are affected by conditions of humidity and temperature in the storage environment. The dry seed of common beans contains about the same moisture percentage as the small grains (13 to 17 per cent). It is, however, relatively higher in protein and fat and lower in carbohydrates.

Typical of other legumes the seed is bi-valved, the two halves closely compressing between themselves the embryonic plant or germ, the whole being inclosed within a relatively tough integument or seed-coat. The embryo is usually attached to the cotyledons at or near one end of the seed, the seed being attached on its ventral side to the pod in which it is borne. The character of the seed and its epigenous method of germination are illustrated in Fig. 7.

The cotyledons of the bean seed serve a dual purpose not common to the seed of non-leguminous plants. These serve not only as a source of reserve food for the embryo

FIG. 7.—Stages in the epigenous germination of the common kidney bean. (1) Seed showing (*a*) hilum, or seed scar; (2) Cotyledon bearing embryo, (*a*) radicle (*b*) plumule, or first leaves; (3) and (4) epicotyl breaking ground; (5) (*a*) epicotyl, (*b*) cotyledon, (*c*) old seed coat; (6) first pair of true leaves emerging; (7) young plant showing (*a*) stem, (*b*) old cotyledon, or seed-half, (*c*) developing stem, (*d*) first pair of true leaves.

plant, but also as a shield protecting the tender young seedling as it breaks through the surface soil. As the seedling emerges, the cotyledons spread apart to func-

tion briefly in photosynthesis while the first pair of true leaves are developing. The former soon drop off and the terminal bud gives rise to further growth of stem and the permanent trifoliolate leaves.

### SEED QUALITY

Good quality in bean seed requires that it be viable, free from seed-borne diseases, free from varietal admixture, uniform in size, type and color, free from broken, split, discolored and wrinkled beans, and true to a standard name. To insure such quality, seed production requires not only scientific methods, but the utmost care on the part of the producer. The production of seed of all but the more common strains of dry field beans is a specialized enterprise of commercial seedsmen and bean-breeders. Although beans are normally entirely self-pollinated, a certain amount of insect pollination by bumblebees occurs where precautions against it are not taken.

Good one-year-old bean seed should germinate at least 90 per cent. Brown[1] of the United States Department of Agriculture tested ninety-eight commission packets of seed beans purchased in eight states and found the average germination to be 84.9 per cent. The longevity of bean seed varies from two to three years and is dependent mainly on the humidity conditions of its storage. The viability depreciates more rapidly under high humidity than under low.

Although temperature is apparently much less influential on the longevity of seed than is humidity, it is, nevertheless, of much importance in its relation to ger-

[1]Brown, Edgar I. "The Germination of Vegetable Seeds." U. S. Dept. Agr. Bur. Pl. Ind. Bull., 131, p. 6 (1908).

mination and growth. This is well illustrated in data obtained by Reynolds[1] and shown in Tables XIII and XIV.

TABLE XIII

NUMBER OF DAYS REQUIRED FOR FIRST APPEARANCE OF RADICLE IN GERMINATION AT VARIOUS TEMPERATURES.

| Crop | Temperature Range in Fahrenheit | | | | |
|---|---|---|---|---|---|
| | 45°-55° | 55°-65° | 68°-72° | 80° | 90° |
| Beans | 19 | 4 | 3 | 3 | 2 |
| Dent corn | .. | 3 | 3 | 2 | .. |
| Smooth peas | 7 | 5 | .. | 4 | 4 |
| Wrinkled peas | 11 | .. | 5 | 4 | .. |
| Onions | 14 | 3 | .. | 2 | .. |

The above data indicate that the optimum germination temperature for beans is not only high, but relatively higher than for the other crops tested. This fact is still further emphasized in further data by Reynolds in Table XIV.

All these tests were made in a water-jacketed oven. It is usually not advisable to employ seed which is more than two years old. If older than this, the amount of seed to the acre should be increased according to the subnormality of the germination. Old seed and seed suspected of being immature should not be used unless by a careful germination test its merits have been proven.

The germination test for beans is comparatively simple since under favorable conditions of temperature and moisture not more than four to five days are required for its completion. A simple method advocated for

[1]Reynolds, J. B. "Temperature in Relation to Seed Germination." Ont. Agr. Coll. Rept. 29, pp. 9-11 (1904).

TABLE XIV

RELATION OF TEMPERATURE TO OPTIMUM GERMINATION

| Crop | Best Temperature | Second Best Temperature | Third Best Temperature | Remarks |
|---|---|---|---|---|
| Beans..... | 90° F | 80° F | 68-72° F | Mildewed at 95° F |
| Dent corn.... | 80° F | 90° F | 68-72° F | Some mildew at 80° F |
| Smooth peas.. | 80° F | 68-72° F | 55-65° F | Vitality destroyed at 90° F |
| Wrinkled peas | 68-72° F | .... | .... | |
| Wheat..... | 68-72° F | 55-65° F | 80° F | Vitality impaired at 80° F |
| Cabbage..... | 80° F | 68-72° F | 90° F | Vitality impaired above 80° F and below 68° F |
| Tomato..... | 90° F | 80° F | 68-72° F | Vitality impaired at 95° F |

growers is to count out a hundred seeds chosen at random and place them in a tray or deep plate between pieces of moist blotting paper. Sufficient water should be provided below the blotting paper to insure against drying before the germination period is completed. A second tray should be inverted over the seed to provide a moist chamber. The test should be run in a warm room where the temperature range will not vary from 80° to 90° Fahrenheit. Wet beans are very subject to decomposition and the growth of molds, hence previous sterilization of the test pads, seeds, and trays with a 2 per cent solution of mercury bichloride or copper sulfate is recommended. In computing the percentage germination, only vigorous sprouted seeds should be counted.

This takes into account the fact that seed may possess sufficient vitality to rupture the seed-coat and at the same time be too weak to break ground and produce a strong plant. The sand-box method of testing provides a more certain criterion of vitality in such cases.

### SIZE OF SEED

There are two phases of this factor, both of some importance. Standard varieties differ in size of seed, also there is frequently much variation in size within a given lot of seed. In general, the larger seeded varieties require a larger volume of seed to plant a given area than do the smaller seeded sorts. Among 351 growers in New York in 1917 it was found that the pea, medium, marrow and kidney varieties were seeded at the average rates of 48.1, 62.7, 72.8, and 73.9 pounds to the acre respectively. The author determined by count that one pint (15 ounces) each of the varieties Improved Michigan Pea, Blue Pod Medium, Boston White Marrow, and Red Kidney contains 1,541, 1,265, 862, and 687 seeds or an approximate ratio of 9–7–5–4 respectively for the four types represented by these varieties. This is in approximate accord with figures furnished by Hendry[1] for eleven distinct types.

The comparative value of large and small seed within a given lot or strain appears to be an unsettled question. Experimental results have not sufficiently demonstrated the superiority of large seed to cause any general tendency on the part of growers to grade seed for size. The data obtained by Rudolfs (Table VIII) indicated a more rapid germination and early growth from

[1] Calif. Agr. Exp. Sta. Bull. 294, p. 46 (1921).

large than from small seed. An early experiment by Churchill[1] using large and small seed selected from the variety Golden Wax and planted in alternate rows of several replications gave results consistently in favor of the large seed by an average gain of 19 per cent in the yield of grain. Although the small seed usually germinated more quickly, the large seed ultimately gave more vigorous and higher yielding plants.

Harris[2] was able to distinguish what he terms a distinct differential mortality in common beans, *P. vulgaris*, by grading a large quantity of seed into different weight classes and measuring biometrically the ability of these respective classes to produce mature fertile plants. As a result of these experiments, the author concluded that "seeds which produce fertile plants are on the average neither lighter nor heavier than random samples of the same population."

Probably the best information on this subject is that furnished by Cummings[3] from a three-year test at the Vermont Experiment Station. Using the variety Golden Wax which he says commonly shows distinct variation in size of seed, he sorted it into large, medium, and small sizes and planted in alternate rows. A part of his results for the first year of the test are given in Table XV.

[1]Churchill, G. W. "Large versus Small Seed." N. Y. (Geneva) Agr. Exp. Sta. Rept., pp. 364-368 (1889).

[2]Harris, J. Arthur. "On Differential Mortality with Respect to Seed Weight Occurring in Field Cultures of *Phaseolus vulgaris*." Amer. Nat., Vol. 46, pp. 512-525 (1912)

[3]Cummings, M. B. "Large Seed a Factor in Plant Production." Vt. Agr. Exp. Sta. Bull. 177, pp. 104-108 (1914).

TABLE XV

RELATION OF SIZE OF SEED TO YIELD IN GOLDEN WAX BEANS (1910).

| Size | Number of Seeds Used | Weight of Seed Used (Grams) | Yield of Beans (Grams) |
|---|---|---|---|
| Large..... | 500 | 312 | 964 |
| Medium..... | 500 | 252 | 624 |
| Small..... | 500 | 169 | 567 |

These results certainly show much in favor of large seed. Cummings continued the experiment by further selecting large seed from the large, large from the small, small from the large, and small from the small, and claims to have secured best results from the selection of large seed from large and poorest results from the small from small seed selection. The low yield obtained from the small seed the first year (1910) was due, he explains, to the fact that these plants set fewer pods by 52 per cent.

### SOURCE OF SEED

Most growers of dry-shell beans raise their own seed, those with a large acreage usually having it cleaned and hand-picked at the local bean elevator. Market-gardeners, truck-gardeners and growers of cannery beans, on the contrary, very generally obtain their seed supply from commercial seedsmen or from canners who have it grown under special contract for them. In the case of the canning crops grower this is undoubtedly good practice. The grower is thereby relieved of the responsibility of finding a source of seed which will produce a type and quality of bean which will satisfy the canning trade. Market- and truck-gardeners will do well to buy seed from large commercial seedsmen who specialize in beans.

Locally grown seed, already acclimatized, other things being equal, is better than seed raised in a distinctly different climate. Clean seed, threshed from clean disease-free pods, from a high yielding strain is recommended.

The demand for disease-free high yielding seed of improved strains and varieties has recently resulted in a system of seed inspection and certification of beans produced under approved methods in New York. Only certain improved strains of known origin are eligible to the inspection service. Certified seed, so produced, usually sells at a premium among growers of field beans. That portion of the New York certification standard for 1926 which relates to the maximum tolerances of diseases, admixture, and defective seed is given in Table XVI.

TABLE XVI

1926 Certification Standard for Seed Beans, New York Seed Improvement Coöperative Association, Inc.

| Factor | Field Inspection (Per cent) | Threhed Samsple (Per cent) |
|---|---|---|
| Anthracnose | 1.0 | 0.5 |
| Bacterial blight | 10.0 | 2.0 |
| Mosaic | 1.0 | ... |
| Varietal mixture | 1.0 | 0.5 |
| Badly wrinkled, discolored and small seed | ... | 5.0 |
| Minimum germination | ... | 90.0 |

Seed to be eligible for certification must be graded according to the grading rules of the New York State Bean Shippers' Association.

## CHAPTER VIII

## *PLANTING AND CULTIVATION OF BEANS*

Time, method, spacing, depth, and amount of seed are factors of importance to be considered in planting beans. Each of these factors as related to practice in a given region should depend on seasonal, soil and economic conditions specific to the locality.

### PLANTING

*Time of planting*

In general, beans are planted at a time closely corresponding to that of corn. However, being perhaps even more sensitive to soil-moisture and temperature conditions, the planting date for the farmer may very well be somewhat later. Although generally planted in the spring, the crop is sometimes seeded in the fall and winter in the South and Southwest. Planting should always be deferred until all danger of killing spring frost is past, and until the seed-bed is thoroughly warmed, well prepared and in optimum moisture condition. The average planting dates in Michigan and New York vary from June 1st to June 15th. It has been shown repeatedly that the later planted crop in these and adjacent states escapes infection with bacterial blight and anthracnose and the bad effects from cold wet soil and the seed corn maggot or bean maggot, whereas the early planted crop may be damaged seriously.

Time of planting experiments covering several years

at the New York Agricultural Experiment Station (unpublished) have shown that by planting the Red Kidney variety as late as June 20th, the crop not only escapes the blight disease and maggot injury but also yields a larger crop of better colored higher quality beans. In California, according to Hendry,[1] "common beans (*Phaseolus* varieties) succeed best when planted late (after June 1) in the interior districts and when planted early (before May 10) in the coast districts." This statement is borne out by experiments at Davis and Berkeley, California, in 1917, the results of which are summarized in Table XVII.

TABLE XVII

EARLY VERSUS LATE PLANTING IN CALIFORNIA, 1917

| Variety | At Davis | | At Berkeley | |
|---|---|---|---|---|
| | Planted May 1 Yield to the Acre (Pounds) | Planted July 2 Yield to the Acre (Pounds) | Planted May 1 Yield to the Acre (Pounds) | Planted June 15 Yield to the Acre (Pounds) |
| Lady Washington | 197 | 486 | 1680 | 582 |
| Pink | 374 | 682 | 1512 | 509 |
| Red Kidney | 74 | 438 | 1153 | 545 |
| Red Mexican | 188 | 1114 | 1601 | 582 |

Early planting in the coastal districts obviates the necessity of irrigation, while the crop in the interior must depend on irrigation and here late planting tends to avoid the damaging influences of hot weather.

*Methods of planting*

Hand planting is no longer practiced extensively except

[1]Calif. Agr. Exp. Sta. Bull. 294, p. 43 (1921).

by home and market-gardeners. This method has the disadvantages of being laborious and of not dropping the seed at a uniform depth. It does, however, offer the advantage of planting in checks so as to allow of cross cultivation. Most of the large commercial acreages are now machine-planted. In New York, approximately 75 per cent of the dry-shell bean acreage is planted with

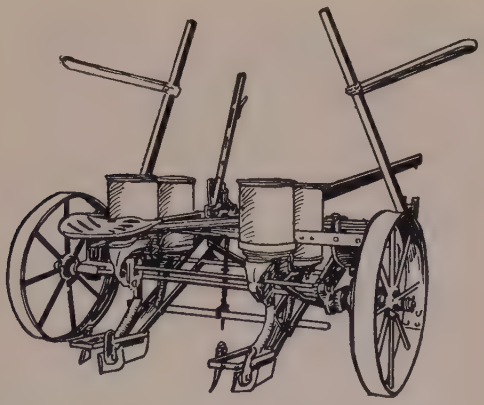

Fig. 8.—A two-row corn- and bean-planter.

the common grain-drill, most of the remainder being planted with corn- and bean-planters (Figs. 8, 9). The latter can be equipped to drop the seed in hills but not so as to permit of checkrowing. When seven-inch row grain-drills are used, the rows are most commonly 28 inches apart, all drill hose being stopped except the second, sixth, and tenth. In the semi-arid bean districts of the West, it is customary first to subirrigate the land and then to prepare it for planting by the ridge and furrow system. Lister planters which place the seed in the

bottoms of shallow trenches are used on soils deficient in surface moisture.

*Plant spacing*

The best distance at which seed should be spaced in the row naturally depends on the habit of growth of the variety, the available supply of soil-moisture and fertility, and to a lesser extent on the method of cultivation

FIG. 9.—Grain-drill equipped to seed beans.

to be employed. Ordinarily, common beans should be spaced with single plants 6 inches apart in the row in rows 28 inches apart, while larger more spreading types should be spaced farther apart in wider rows. For many years, the custom was to plant beans in hills of three to five plants spaced 2 to 3 feet apart. With the development of modern bean machinery and information tending to show advantages in drill row planting, the latter has come to be the prevailing method. The results of several

experiments to test the comparative merits of both methods are on record.

Among the oldest experiments are those of Halsted [1] in 1894 in which he used the variety Golden Wax. Using rows 20 inches apart, he compared plant spacings of 3, 6, 12, and 24 inches in the row and found that yield of both plant and pods decreased as the spacing increased. He also found that the amount of anthracnose was much greater on the closely spaced plants. A year later (1895), he compared yields from spacings of 4½, 9, and 18 inches and obtained similar results.

A more comprehensive test was made by Jordan [2] at the same station in 1897. To determine the best number of plants to a foot of drill row he compared a green-pod and a wax-pod variety in duplicate rows, the plants being spaced at the rate of 2, 4, 6, 8, and 10 to a foot. One quart of seed at each of these thicknesses planted 810, 405, 270, 203, and 162 feet of row respectively. His results are given in Table XVIII.

Indicative of the effect of thickness of planting on earliness of maturity, these data show that the percentage of first pick increased up to six plants to a foot and decreased with the thickness of planting beyond this rate. Although the yield to a vine decreased as thickness of planting increased, the total yield to a foot of row was highest from the thickest planting.

Gillis [3] studied various rates and methods of planting

[1] Halsted, B. D. "Report of the Botanist." N. J. Agr. Exp. Sta. Rept., pp. 290-292 (1895).

[2] Jordan, A. T. "Thickness of Planting." N. J. Agr. Exp. Sta. Rept., pp. 166-167 (1898).

[3] Gillis, M. C. "A Study of the Relation of Method of Planting to Yield in Beans." Thesis (unpublished), Cornell Univ., pp. 1-63 (1924).

TABLE XVIII

THICKNESS OF PLANTING TEST WITH GARDEN BEANS AT THE NEW JERSEY EXPERIMENT STATION—1897

| Variety | 2 to a Foot | | 4 to a Foot | | 6 to a Foot | | 8 to a Foot | | 10 to a Foot | |
|---|---|---|---|---|---|---|---|---|---|---|
| | % First Pick | Yield to a Vine Ozs. | % First Pick | Yield to a Vine Ozs. | % First Pick | Yield to a Vine Ozs. | % First Pick | Yield to a Vine Ozs. | % First Pick | Yield to a Vine Ozs. |
| Flageolet Wax.... | 53 | 1.37 | 55 | .64 | 56 | .57 | 57 | .38 | 53 | .35 |
| Earliest Red Valentine..... | 40 | 1.92 | 42 | 1.03 | 54 | .69 | 48 | .56 | 49 | .46 |
| Ave. of 2 varieties..... | 47 | 1.62 | 49 | .84 | 55 | .63 | 53 | .47 | 51 | .41 |
| Yield from 12 feet of row..... | | 39.6 | | 40.3 | | 45.4 | | 45.1 | | 49.2 |

with both field and garden varieties during the years 1921-1923. Although unfavorable seasonal conditions each year viciated his results, all his plantings were replicated three times and the results carefully analyzed biometrically. With reference to the four varieties of field beans used he says, "For 11 out of 12 trials extending over the three-year period drilling gives better yields than do hills spaced 15 inches apart. In 8 out of the 12 trials, drilling at 4 pecks per acre gives better yields than does hilling at the same rate." In order to compare the response of both large- and small-vined types of garden beans in this study, Gillis used the varieties Red Valentine, Burpee's Stringless Green Pod and Refugee. With spacings at 3, 6, and 9 plants to a foot he found that "the optimum rate for small and medium growing types of garden beans is 9 plants per foot, and for the large growing type it is between 6 and 9 plants per foot or possibly nearer 6 plants per foot. A 'too thin a rate of planting'

is more effective in reducing the yield of the small types of gardens beans, while crowding has the greater effect in reducing the yield of the larger growing type." The spacing recommended in dry-land bean production is somewhat wider than in regions of ample soil-moisture. Whereas approximately 4 pecks of seed to the acre is optimum for the smaller-seeded kinds of field beans, marrow and kidney varieties usually require 5 to 6 pecks for best results.

*Depth of planting*

As previously indicated, the epigenous germination of the bean requires that soil preparation and depth of planting be so regulated as to offer least resistance to the germinating seed. A rapid early growth of the seedling is closely correlated with plant vigor and yield. The seed should be planted only deep enough to insure a proper supply of moisture for germination. In the humid regions, this depth is less in heavy than in light soils, usually 1 to 2 inches in the former and 2 to 3 inches in the latter. Garcia [1] planted the five standard varieties grown in New Mexico at successive inch interval depths of 1 to 5 inches on both wet and dry soils during the years 1914 and 1915. In no case was the germination optimum at the 1 inch depth, on account of the rapid drying of the soil. The 2 and 3 inch depths were most satisfactory in both wet and dry soils, although where the soil is to be subirrigated the author recommends planting no deeper than 1 or 2 inches while if planted on naturally moist soil the depth should be 3 to 4 inches. Planting too deep

[1] Garcia, Fabian. "New Mexico Beans." New Mex. Agr. Exp. Sta. Bull. 105, pp. 17-21 (1917).

in heavy wet soils frequently results in not only a retarded germination attended by loss of vigor in the seedlings but also serious injury from the bean maggot.

### CULTIVATION

The bean plant, more than most other cultivated crops, is easily pulled from the ground, injured, and broken

FIG. 10.—Sulky cultivator used in cultivating beans.

over by harsh cultural treatment. This is partly on account of its sparse shallow root system. Also among vegetables, it has a comparatively poor capacity for root replacement. Nevertheless, the crop responds to clean cultivation and it does not well withstand weed competition. Two-row sulky cultivators equipped with narrow

teeth are commonly used on the commercial acreages (Fig. 10). Covering over the young plants as they emerge from the soil is not advisable as beans do not benefit from this practice in contrast to what is thought true in the case of potatoes. To avoid covering, guards are sometimes attached to the cultivator next those teeth closest to the row.

Thoroughness of seed-bed preparation before planting is especially important as a means of avoiding the necessity of late-season cultivation to control weeds. Three to five cultivations should be sufficient and these should be done early and shallow to avoid injury to the roots. It is not advisable to cultivate beans when the foliage is at all wet on account of the danger of speading, by contact, the spores of the fungus causing anthracnose or pod-spot. The often expressed notion that the crop should not be cultivated when the plants are in blossom has no justification in proof.

## CHAPTER IX

## *DISEASES OF BEANS AND THEIR CONTROL*

THERE are several disease-producing organisms parasitic on beans, only a few of which are usually of serious consequence to the crop of a given region in any given year. Certain of these may affect markedly not only the yield but the marketability of the crop. In general, bean diseases are more prevalent in humid than in dry regions. The crop grown in California, Colorado and adjacent states of relatively low rainfall is seldom affected by disease. This, coupled with the fact that very little weathering of the mature seed occurs, is ample reason for the extensive production of seed stocks in some of the semi-arid western states. Yields are frequently very much reduced in the Great Lakes states and in New England by such diseases as anthracnose, bacterial blight, and dry root-rot. Bean rust, not at all serious in the northeastern states, is one of the most troublesome in the south Atlantic truck-crop sections. Burkholder [1] has formulated the following descriptive key to the more common bean diseases according as they affect the plant parts above or below ground:

[1] Burkholder, Walter H., and Hawley, I. M. "Diseases, and Insect and Animal Pests, of the Field Bean in New York." Cornell Univ. Extension Bull. 58, p. 5 (1923).

*A Descriptive Key to Bean Diseases*

On the plant parts above ground

1. Areas on veins on under sides of leaves trun black; dark, circular, sunken spots appear on pods, and similar spots are found on the stems of the seedlings; most serious in rainy seasons .....Anthracnose
2. Large, brown, dead areas form on the leaves; watery, irregular spots appear on the pods, and these later turn reddish and become sunken; at times there is a rotting of the stem at the first joint.....Bacterial blight
3. A tip-burning of the leaves and a dwarfing of the plant occur; also, a decided wilting of a part, or the whole, of the plant Bacterial blight
4. Dwarfing, mottling, and crinkling of the leaves occur; in many instances, the plant grows bushy and remains green until frost; few or no pods set; found more generally on the pea and medium varieties of field beans.....Mosaic
5. Small, powdery, brown pustules occur on the leaves, stems, and less frequently, on the pods; disease appears late in August .....Rust
6. A rotting of the stems and the pods of the plant takes place, accompanied by a cottony growth, and small, black, hard bodies about ⅛ or ¼ inch in diameter are formed; disease occurs in rainy seasons, or in damp, shady places Sclerotinia rot
7. Plants dwarfed; such varieties as the marrow and pea fail to vine; few pods produced; leaves turn yellow and drop prematurely; more severe in dry weather.....Dry root-rot

On the plant parts below ground

1. Tap-root is at first red, but later becomes brown and dried; frequently a mat of surface roots produced; more serious in dry weather.....Dry root-rot
2. Tap-root reddish at first, but later coal-black lesions with a frosty appearance in wet weather form on roots; most severe on seedlings and in cool weather.....Black root-rot
3. Brick-red, sunken blotches on lower stem and on tap-root; seldom severe.....Rhizoctonia blotch

## ANTHRACNOSE (Figs. 11-14)

Anthracnose is commonly referred to as pod-spot from the fact that its most prominent symptom is the large

rounded dark-colored lesions on the pod. The presence of an orange-colored border around the larger of these pod lesions probably accounts for the term "rust" which is sometimes erroneously applied to this disease by the lesser informed growers. The disease is most prevalent

FIG. 11.—A hill of beans badly affected with Anthracnose.

in rainy seasons throughout the humid sections of the United States.

*Symptoms*

Attention is first attracted to the large pod lesions

described above. These pod-spots when small or newly formed may be difficult to distinguish from the lesions caused by bacterial blight. They differ mainly in that they are usually more rounded and more clearly defined in outline, the centers often raised and of a black color with an orange border. Similar lesions occur on the seedlings while the cotyledons usually bear black discolorations representing the counterpart of the lesions on the pod from the parent plant. Anthracnose is easily overlooked on the leaves as the fungus of the causal organism is mainly restricted to the veins and shows black on both upper and lower leaf surfaces. The leaf tissue is seldom killed to such an extent as to make the disease readily noticeable.

*Cause*

The disease is caused by the fungus *Colletotrichum lindemuthianum* which over-winters in the seed. Infected seed, when planted, produces cotyledons bearing a mass of spores which serve as a source of infection for the entire field. Under moist conditions, these spores may wash down over the seedling stem, on to the newly formed leaves and pods and thence by contact carriers or wind to adjacent plants. Late in the season the fungus mycelium may work its way through the pod on to the seed. Thus the cycle is completed and the organism is carried over to furnish possible infection to succeeding crops.

*Control*

No method of control, once the disease has started in the field, has been satisfactory. Two recourses whereby anthracnose can be largely avoided are possible. These

are the use of disease-free seed from clean pods and disease-resistant varieties. To avoid the necessity of hand-picking a sufficient number of clean pods for the entire seed supply, a carefully tended isolated seed-plot should be grown. This should be located at least fifty

FIG. 12.—Seedlings affected with bean Anthracnose.

rods from other bean fields to avoid contamination, cultivated only when the plants are dry, and carefully rogued of all off-type and diseased plants throughout the growing season.

The most satisfactory control is to use disease-resistant varieties. Several of these are now available. The Wells Red Kidney is very resistant to the most common strains of anthracnose. It was found originally in a

FIG. 13.—Anthracnose on (left) wax-podded and (right) green-podded string-beans.

field of common Red Kidney in New York. White Imperial is very resistant to the disease but has the disadvantages of being very late and rather unpopular as a market variety. A strain of white marrow known as Nova Scotia and recently introduced from Nova Scotia is somewhat resistant. The white marrow variety known as Perry Marrow was developed at the Perry Bean Laboratory, Perry, New York, out of a cross between the common white marrow and Wells Red Kidney. This is apparently immune to anthracnose and

FIG. 14.—Seed of medium beans affected with anthracnose.

is rapidly superseding all other varieties of this type. Michigan Robust Pea is quite resistant to anthracnose and because of its general resistance to most other bean diseases should supersede other less valuable varieties of the pea type.

### BACTERIAL BLIGHT (Figs. 15, 16)

Unlike anthracnose, bacterial blight cannot be controlled in appreciable extent by the use of resistant varieties. It is probably the most prevalent and damaging of any of the bean diseases in the leading field bean states. Kidney varieties are most susceptible. Since the disease commonly kills a part or all of the plant sometimes prematurely, serious infection of the crop may result in almost total loss. Blight was notably prevalent and caused enormous losses to the crops of 1925 and 1926 in New York and adjacent states.

*Symptoms*

Usually the first evidence of bacterial blight is the appearance of small, irregular, amber-colored, water-soaked spots. These spots may become rapidly larger and produce much dead tissue, eventually involving the whole plant. Sometimes in hot seasons infection may occur early enough to prevent the proper filling of the pods. Similarly, the plant may be killed prematurely with the result that much of the seed will be imperfectly developed. The pod lesions are usually of reddish color, water-soaked in appearance and very irregular in outline. These symptoms, coupled with the fact that the lesions never develop the dark centers characteristic of anthracnose spots, may be used to distinguish the latter disease from blight.

Blight on the pods is sometimes confused with sunscald. Such confusion can be avoided by noting that sunscald affects mainly that side of the pod exposed to the sun. As with anthracnose, if the causal organism penetrates the pod sufficiently, the developing seed is

infected and the disease is then likely to carry over to the next year's crop. Blighted seed is sometimes difficult to diagnose and may be confused with weathered seed or seed discolored by anthracnose. Usually the discoloration from blight is yellow and not clearly defined in out-

FIG. 15.—Bacterial blight on bean leaf.

line. In case of serious infection, some seed may be even shrivelled or badly wrinkled. Lesions occur on the stem in the form of longitudinal dashes and when severe a reddish-brown decay at the first or second node may cause the plant to break over. A less common symptom of blight is the sudden wilting and dying of the entire plant without the appearance of any of the external symptoms described above.

*Cause*

The organism causing blight is a bacterium known as *Bacterium phaseoli,* E. F. Smith. It infects the seed and there it over-winters and may persist for several years. Dissemination may occur in two ways. When the seed germinates, the bacteria become active in the cotyledon and from it they may be either carried from plant to plant by wind, rain, and insects, or enter the water vessels of the seedling tissue direct and thereby cause the wilting already described.

*Control*

Only seed known to have come from fields free of the blight should be used. Since the disease is seldom of equal prevalence throughout a given region, bean-growers would do well to search out the cleanest seed available after a year of bad blight. The use of a seed-plot is recommended. There is great need for blight-resistant varieties. Though many varieties and strains have been tested for resistance, none has been found except the Michigan Robust Pea. This variety has proven fairly resistant to most bean diseases. Soaking seed for twenty minutes in 1-50 benetol or 1-1000 corrosive-sublimate has given some measure of control in certain of the

southern states but it has not been tried commercially in the North. There is always danger of injuring germination of the seed by the soaking process necessary in such treatment.

### DRY ROOT-ROT (Fig. 17)

This disease was comparatively little known prior to 1917 and is even yet seldom found outside of western New York. A little over a decade ago, dry root-rot was found to cause serious losses to the crop grown on the older bean soils of western New York. All the standard types and varieties, so far as is known, are about equally susceptible. The disease seems to be most damaging in seasons having dry hot summers.

*Symptoms*

The most outstanding symptom is a more or less stunted plant with a partially decayed reddish-brown tap-root. The root decay is essentially dry and may result in almost total destruction of the fibrous lateral roots. Sometimes only a few lateral surface roots are left to furnish mineral nourishment for the plant. As a result, the plant may die prematurely or at best produce a very much reduced yield. The disease is often the cause of failure of trailing varieties to vine.

*Cause*

Dry root-rot is caused by the fungus *Fusarium martii phaseoli,* Burk. This fungus lives in the soil and may persist for many years even in the absence of the bean plant. It also over-winters in bean trash left after harvest and in manure from live-stock fed on diseased bean roughage.

Fig. 16.—Bacterial blight on pods of the Red Kidney variety.

*Control*

It is difficult to control dry root-rot because of its method of over-wintering and its extreme persistence in the soil. Land known to be infected should not be planted to beans and manure likely to be infected should never be applied to land in preparation for this crop. Long rotations will tend to decrease losses from the disease. Shallow cultivation of the infected crop in order to avoid cutting off the scanty supply of surface roots is recommended. Unfortunately, no standard variety very resistant to dry root-rot has been developed.

### MOSAIC

One of the most recent diseases to cause damage to beans is mosaic. It was first reported from western New York in 1916, and by 1918 many growers of pea beans had gone out of bean-growing on account of it. The disease has been reported in Michigan but does not seem to be a factor of importance in other important bean-growing states. Fortunately, only varieties of the pea and medium types seem to be very susceptible.

*Symptoms*

Mosaic symptoms appear principally on the leaves in the form of a blotching and a crinkling similar to that found on other plants. Various types of abnormalities due to malnutrition and other diseases occurring in beans may be taken for mosaic. However, true bean mosaic produces a distinct downward cupping as well as a distinct blotching which, when once identified, is not easily overlooked. Affected plants are usually paler green and more dwarfed than healthy individuals. An early infec-

tion may cause complete failure to pod and some defoliation while late season infection may reduce the yield very little.

*Cause*

Although the cause of mosaic has not been definitely defined, it is apparently due to a virus which is transmitted in a way similar to that common to many other economic plants. Insects apparently transmit the disease and it is known that mosaic is carried over in the seed from year to year.

*Control*

Ordinary control measures, such as seed treatment, spraying, dusting, and even the use of seed from apparently healthy plants, will not control mosaic. The use of resistant varieties is the only safe precaution against it. The Michigan Robust Pea is almost immune and is rapidly superseding all other varieties of pea beans in New York and Michigan. It was originally found by F. A. Spragg[1] in 1908 at the Michigan Agricultural College among a lot of commercial beans containing mosaic. The Red Kidney, White Marrow, Yelloweye and at least most varieties of string-beans are not injured to any extent by the disease.

RUST

Bean rust is essentially a warm-climate disease which seldom occurs in the more important bean states of the humid regions, and even then usually appears so late as

[1]Spragg, F. A., and Down, E. E. "The Robust Bean." Mich. Agr. Exp. Sta. Special Bull. No. 108 (1921).

FIG. 17.—A White Marrow bean plant affected with dry root-rot.

to do very little damage to the crop. It is most serious in the southwestern and south Atlantic states in the hotter drier seasons.

*Symptoms*

The rust spots are most noticeable on the leaves although they occur, always in smaller numbers, on the pods and stems. They consist of pustules about the size of pin-heads and are of a rusty color. When mature, they liberate a mass of spores which easily rub off. The spots occur on both upper and lower surfaces of the leaves.

*Cause*

Bean rust is caused by the fungus *Uromyces appendiculatus*. It produces the reddish brown summer spores during the growing season and later on the winter or resting spores. The latter give the appearance of minute black specks on both leaf surfaces. These spores overwinter on the leaves and trash left in the old bean field.

*Control*

According to the Virginia Experiment Station, Red Kidney, White Marrow, and Birdeye varieties are very resistant to rust while the Navy Pea is very susceptible. The use of resistant varieties and the burning of old bean trash in the field are recommended means of control.

### MINOR DISEASES

A few bean diseases occur in certain seasons and under specific conditions but none of them is generally serious enough to warrant much attention to control measures.

*Black root-rot*

This has been observed in a few areas of western New York. It appears early in the season under cool weather conditions first as a reddish discoloration of the tap-root and later as a black lesion. Although some of the root system may be destroyed, the plant usually outgrows the disease during the warmer months of the growing season. Black root-rot is caused by the fungus *Thielavia basicola.*

*Rhizoctonia*

The fungus Rhizoctonia occurs commonly on roots of the bean producing brick-red lesions, irregular in shape and depressed on the tap-root. While the symptoms may be confused with those of dry root-rot, it seldom produces a noticeable effect on yield or growth of the plant.

*Sclerotinia rot*

The most obvious symptom of this disease is a cottony white mold occurring on the pods and stems at the base of plants growing in low wet spots in the field. It is caused by the fungus *Sclerotinia libertiana.* The fungus produces a soft, brown, slimy decay of the pods which lie in contact with wet soil or under poorly aerated and poorly drained conditions. Proper spacing of the plants, good drainage, and clean cultivation are ordinarily sufficient to avoid loss from the disease.

*Sunscald*

This trouble can scarcely be classed as disease since it is caused by exposure of the tender pods to hot sun The symptoms are sometimes confused with those of bacterial blight. The discoloration of the pod, however,

is confined mainly to the one side exposed and the affected areas are seldom sunken to the extent found in bean blight. Sunscald is of no commercial consequence in dry-shell beans but may seriously reduce the marketability of string-beans by disfigurement of the pods.

## CHAPTER X

## *INSECTS AND THEIR CONTROL*

The annual loss from damage to the bean crop caused by insects is not usually as great as that due to diseases. Nevertheless, there are no less than ten distinct species of insects which prey upon the crop in certain regions under seasonal conditions favorable to their development. Four of these may be said to be of major importance in view of the very serious damage each may cause in certain seasons. These are best known by such names as the Mexican bean beetle, the bean weevil, the bean maggot, and the field gray slug. Insects that occasionally attack the bean plant but which are generally of lesser importance are the bean ladybird, flea-beetle, aphis, thrips, leaf-hoppers, and the red-spider or plant mite. Some of the above insects are prevalent only in restricted areas, others are seasonal, while a few are widespread throughout the bean-growing states.

Control measures have consisted mainly in so regulating cultural practices as largely to avoid these pests. Spraying with arsenicals and nicotine preparations has been practiced to only a limited extent because of the feeling that it is more or less impracticable.

### THE MEXICAN BEAN BEETLE (Figs. 18, 19)

Owing to its destructive nature and rapid spread throughout the southern states since 1920, the Mexican

bean bettle, *Epilachna corrupta,* has recently merited considerable interest among experiment station workers and growers. It was introduced from Mexico into the semi-arid Southwest many years ago but only recently began its spread through and toward the regions growing common field and garden beans. Although most serious in Alabama, Georgia, Tennessee, and Kentucky, it has already reached Ohio and seems likely to endanger the crop of Michigan and New York at some future time.

*Description*

The adult beetle is similar to the commonly known ladybug to which it is related. It is orange in color, nearly hemispherical in shape, about one-fourth inch long and carries eight black spots on each wing-cover. The larva molts three times, increasing in size with each molt until it is about one-third inch long. At the end of its feeding stage, it attaches itself to the under side of the leaf to pupate within a fuzzy orange-colored puparium. The eggs are also orange-colored and are deposited in groups of forty to sixty on the under surface of the leaf. The entire life cycle is only about thirty-three days in warm weather. The adult beetle lives over winter under leaves or in trash about the old bean fields.

*Injury*

The Mexican bean beetle feeds mainly on the common bean and the limas. It occasionally attacks the cowpea and the soybean, but rarely other economic plants. Both the larva and the adult feed ravenously on the under side of the leaves and generally leave only a network of veins as they move from plant to plant. They rarely injure the pods and stems, but virtually kill the plant by almost

complete destruction of the leaves. According to Howard,[1] the beetles may be numerous by the time the first true leaves develop and a crop may be destroyed completely in four weeks.

*Control*

A few species of insects are parasitic on the bean beetle, but none is sufficiently plentiful to check its influence appreciably. Extremely wet and hot seasons are favorable to its control. The most effective control, however, is either dusting or spraying with magnesium arsenate or calcium arsenate. The spray should be applied every two weeks to the under surface of the leaves, beginning about the time the eggs become numerous. Howard [2] recommends using magnesium arsenate as a spray at the rate of about 2 pounds to 100 gallons of water to the acre. If spraying is not convenient, one of the following dust mixtures should be used: (1) Magnesium arsenate, diluted with 3 to 5 parts of hydrated lime, using from 10 to 15 pounds of the mixture to the acre; (2) calcium arsenate, diluted with 9 parts of hydrated lime, using from 15 to 20 pounds of the mixture to the acre; (3) calcium arsenate, diluted with 1 part of fine dusting sulfur and 4 parts of hydrated lime, using from 12 to 15 pounds of the mixture to the acre. Deep plowing to turn under infested bean refuse is recommended as a means of reducing the probable infestation following a year of severe damage.

### THE BEAN MAGGOT

Seed of the common bean is very susceptible to rotting

[1] Howard, Neale F. "The Mexican Bean Beetle in the East." U. S. Dept Agr. Farmers' Bull. 1407 (1924).

[2] Loc cit., p. 13.

when planted in cold wet soil. It absorbs water readily, becomes soft and a ready prey to soil-inhabiting insects. One of the most destructive of these is the seed-corn maggot or bean maggot, *Phorbia fusciceps*.

FIG. 18.—The Mexican bean beetle, *Epilachna corrupta*. (Above, left to right) Eggs, pupa, adult; (below) first to fourth stages of larva.

*Description*

The destructive phase of this insect is a small, white, headless maggot which enters and feeds within the seed soon after it is planted and before the seedling breaks

ground. It is most serious in a cold wet backward spring when conditions are unfavorable for rapid germination and growth. Notable examples of such seasons were 1917 in New York and 1926 in both Michigan and New York. In such years, growers unable to explain what is presumed to be poor germination, on examining the seed find that it is bored through by numerous small maggots. The latter also commonly destroy the first pair of true leaves, giving the young seedlings the appearance of "snake-heads."

FIG. 19.—Plant badly damaged by the Mexican bean beetle.

The maggot is the larva stage of a fly that is similar to but somewhat smaller than the common housefly. It is about one-fifth inch long and greenish gray in color. The elongated white eggs are laid usually during late May and early June. Moist soil containing decaying organic matter is most attractive to the female fly at egg-laying time. The entire life cycle is not longer than a month and two broods in a season are common. The insect over-winters in the pupal stage.

*Injury*

Severity of injury is closely related to the seasonal and soil conditions at or near planting time. When the soil is cold and moist the seed may be entirely destroyed, necessitating replanting. The maggot feeds on the cotyledons, the first true leaves, and may even bore into the tender seedling stalk, causing it to break over. Injured seedlings seldom develop into thrifty plants, but rather remain dwarfed throughout the season or die prematurely.

*Control*

No seed treatment has been practicable in the control of the maggot. Once the latter has become prevalent there is no known method for its eradication. Several recommendations have been effective in avoiding serious damage. Shallow planting in the heavier wetter soils will facilitate quick germination and thereby enable the plant to become established before serious injury occurs. Planting in wet heavy soil containing an abundance of decaying vegetable matter should be avoided. Early and thorough seed-bed preparation and planting after the principal egg-laying period will insure less likelihood of an infestation.

### THE BEAN WEEVIL (Figs. 20, 21)

Probably the best known and most widespread insect which attacks the bean crop is the bean weevil, *Acanthoscelides* (*Bruchus*) *obtectus*. It is responsible for enormous losses in storage every year, and causes what are popularly called "buggy" beans. North of the latitude of Washington, D. C., it is seldom observed in the field, but in the South it is in reality a factor limiting

production of the common *P. vulgaris* varieties. It also attacks cowpeas and common peas in the warmer climates.

*Description*

The primary infestation occurs in the field while the pods and seed are immature. The adult female weevil oviposits in the tender pods, the eggs hatching the tiny white larva within the seed after the latter is in storage. The adult weevil is about one-eighth inch long, grayish-brown, with hairy wing-covers. Under warm storage temperatures, several generations may be produced, the larva eating and developing from the egg to the weevil entirely within the seed. At maturity, the weevil pushes off the seed-coat covering the pupal chamber and emerges. Badly infested beans exhibit many holes and are worthless for either food or seed. On close examination the tiny white eggs may be observed either on or about infested beans in storage.

*Injury*

A vivid description of the method by which weevils get into beans is furnished by Back.[1] A larva hatched from an egg on the surface of a stored bean first tunnels its way into the seed and gradually eats out a larger chamber as it grows to full size. The complete life cycle usually requires four to six weeks and several generations a season are possible. Although the germ is seldom injured, badly infested seed is so weakened as to be capable of producing only weak plants at best.

[1]Back, E. A. "How Weevils Get into Beans." U. S. Dept. Agr. Yearbook (1918). Separate No. 786.

FIG. 20.—The bean weevil, (*a*) adult beetle, (*b*) larva, (*c*) pupa.

*Control*

As previously indicated, the weevil is more prevalent in a warm than in a cool climate. Similarly, it is sometimes observed as early as the harvest period, even in the North in warm dry seasons. It reproduces more rapidly at high than at low temperatures. Dry-shell beans should be stored in relatively cool well-ventilated storage to avoid weevil infestation during the winter months. It has been shown experimentally that temperatures ranging below 50 degrees Fahrenheit are sufficient to check this pest in storage. In case of infestation, two principal control measures are recommended, (1) fumigation and (2) temperature control treatments.

Fumigation with carbon disulfid, using 3 to 5 pounds of the chemical to each 1,000 cubic feet of space, 1 ounce to the bushel, or 1 tablespoonful to each cubic foot of space, is the most common and probably the most efficient control. Carbon disulfid is very inflammable and should not be used in close proximity to fire. It is very penetrating, is heavier than air, hence the liquid should be poured into shallow vessels and set over or above the seed to be treated. The treatment should be done under air-tight conditions for a period of twenty-four to thirty-six hours. Fumigation is most effective if done at a temperature of about 70 degrees Fahrenheit. It may be necessary to fumigate several times during the storage period at intervals of four to six weeks.

Temperature control treatments have been effective, but are practicable only when proper facilities for regulating the temperature are available. Recent experiments in Kentucky have shown that a temperature of 0 degrees Fahrenheit for twenty-four hours will destroy

all stages of the insect. Experiments in California [1] showed that a temperature of 125 degrees Fahrenheit for five hours was fatal to all stages of the horse bean weevil. Hawley [2] states that a temperature of 131 degrees Fahrenheit for one hour is fully effective. Neither the high nor the low temperature treatments seem to injure germination.

### THE FIELD GRAY SLUG

Although not a true insect but rather a snail of the mollusk family, the field gray slug, *Agriolimax agrestis,* may be considered among the more serious insects because of the type of injury it produces. It occurs rather generally throughout bean-growing regions and in wet seasons may cause almost complete destruction of the growing plants. It feeds on many of the other common garden vegetables, being especially partial to the tender leaves. While the younger slugs do not eat the veins and woody portion of the bean leaf, the larger adults commonly devour the entire leaf and eat large cavities into the pod. Most of the injury by slugs is done during the night, the pest seldom appearing in the day.

*Control*

Thorough spraying of both upper and lower leaf surfaces with 4-4-50 bordeaux mixture when the plants are small has been an efficient control. In wet seasons, when the slugs are numerous, the bordeaux spraying may be supplemented by a poison bait distributed between the rows. This bait is made by mixing 1 part, by weight, of calcium arsenate with 16 parts of chopped clover and

[1] Calif. Agr. Exp. Sta. Bull. 294, p. 63 (1921).
[2] Cornell Univ. Extension Bull. 58, p. 37 (1923).

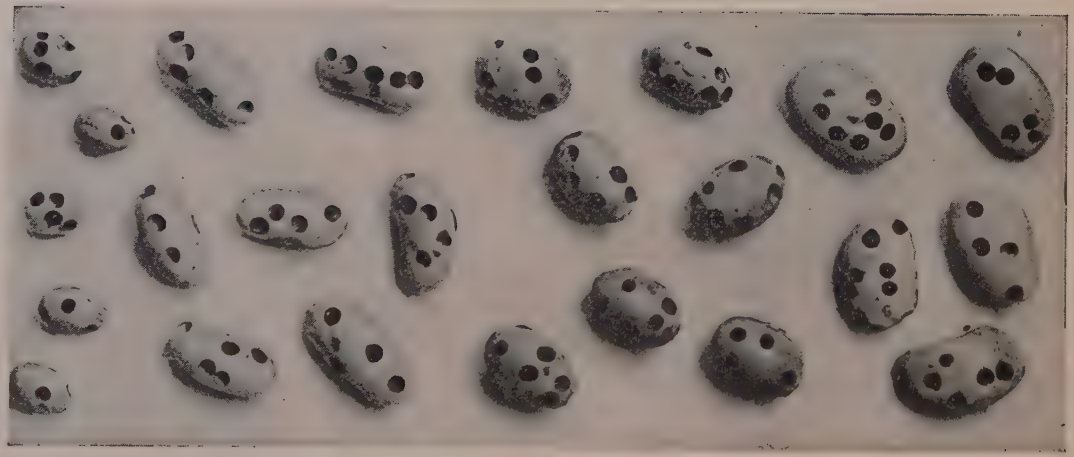

FIG. 21.—Beans badly injured by the weevil.

sufficient water to cause the two ingredients to stick well. Dusting the plants with hydrated lime will also serve as a deterrent. Since slugs commonly pass the winter under weeds, trash, sod, or manure, clean cultivation and thorough decomposition of sod and stable manure will do much to avoid the pest.

### MISCELLANEOUS INSECTS

*Flea-beetles*

Various species of flea-beetles cause injury to beans by feeding on the leaves. The two principal ones in New York are the pole-striped flea-beetle, *Systena tæmata*, and the red-headed flea-beetle, *Systena frontalis*. The former occurs from June to September while the latter is more common from July to October. When numerous, flea-beetles cause the leaves to present a ragged or spotted appearance and later to become yellow. Spraying with 4-4-50 bordeaux mixture poisoned with 3 pounds of paste lead arsenate is recommended for control.

*Bean thrips* (*Heliothrips fasciatus*)

This is a minute insect, both adult and larva of which feed on the under side of the leaves of the plant in California. The adult is grayish black in color with white bands across the wing-covers while the larva are almost transparent with deep red markings along the sides of the body. The principal injury from thrips is a pale discoloration of both leaves and pods, impairing the latter in fresh green-pod form for market purposes. In severe cases, the plants are entirely defoliated. Thrifty vigorously growing plants will ordinarily withstand the attack of thrips. Otherwise, spraying the under side of

the leaves with nicotine sulfate and soap is recommended. The formula recommended is 10 ounces of 40 per cent nicotine sulfate, and 2 to 4 pounds of laundry soap to 100 gallans of water.

*Bean aphis* (*Aphis rumicis*)

The aphis is said to attack nearly all species of beans, but is seldom serious except in the hotter drier seasons. The insect sucks the juice from the under surface of the leaf and, in common with the aphids which attack most plants, it is difficult to control. Spraying with nicotine sulfate as for thrips is recommended.

*Red spider* (*Tetranychus telarius*)

In mild climates, notably in California, a minute plant mite known as the red spider attacks beans and many other species of plants. The insect causes the leaves to turn pale and in severe cases to dry up. In hot weather, the whole life cycle comprises only four to seven weeks and since each female lays from fifty to one hundred eggs, the rate of increase may be such as to result in much damage to the bean crop. The red-spider crawls from plant to plant and to some extent is wind-blown. Control is accomplished best by applying dry sulfur dust at the rate of 20 to 40 pounds to the acre. Several applications may be necessary.

*Bean ladybird* (*Epilachna corrupta*)

A serious pest of beans in the semi-arid Southwest is the ladybird or spotted bean beetle. It is confined mainly to the states of Colorado, New Mexico, and Arizona where its principal host plant is the bean and the soybean. It is related to the beneficial species of lady-

bird insects and is one of the few species which feeds mainly on vegetation. In appearance it is very similar to the Mexican bean beetle. It feeds on all parts of the bean plant above ground but mainly on the foliage. The injured leaf is skeletonized by the adult eating holes from the upper surface while the larva feeds on the lower surface. For control, Chittenden [1] recommends brushing or picking the adult beetles and larva from the plants as they appear early in the season, cleaning trash, in which the adult over-winters, from the field, and spraying with arsenite of zinc or arsenate of lime at the rate of 1¼ pounds to 50 gallons of water.

*Bean leaf-hopper* (*Empoasca mali*)

This is a serious pest on beans in hot dry seasons causing what is popularly spoken of as hopperburn. Like the aphis, it is a sucking insect which feeds on the lower surface of the leaves and is difficult to control. Spraying the under surface of the leaves at the rate of 50 gallons to the acre with 4-4-50 bordeaux mixture to which has been added one-half pint of nicotine sulfate is recommended.

[1] Chittenden, F. H. "The Bean Ladybird and Its Control." U. S. Dept. Agr. Farmers' Bull. 1074 (1919).

# CHAPTER XI

## *HARVESTING, THRESHING, AND STORAGE*

The quality and marketability of dry-shell beans are considerably influenced by the time of harvesting and the method of threshing the crop. Moisture-content of the threshed seed and susceptibility to shattering are factors to be governed in part by regulating the date of harvest. Yet withal, the weather conditions at harvest time may determine success or failure with the crop of any given year. In humid regions there have been many years when well-grown high-yielding crops have been brought to maturity, only to be lost or greatly damaged by wet weather which made it impossible properly to cure them.

### HARVESTING

The best time to harvest beans is when the larger part of the pods are mature, before shattering of the pods and the dropping of many of the leaves has occurred, and when dry weather suitable for curing the crop is predicted. These conditions do not always prevail simultaneously but, nevertheless, maximum yield and quality depend on such factors.

Bean pods ripen progressively upward from the base of the plant, the entire ripening period usually extending over several days. It is not advisable to postpone harvesting until all pods are mature as this would mean

that the pods first ripened would have shattered part of their seed. Furthermore, bean straw to possess high feeding value must retain most of the leaves. Easily shattering varieties should be harvested in a somewhat greener condition than others. Also, harvesting when the vines are moist with dew may avoid some loss from shattering. According to Hendry [1] Blackeyes and Tepa-

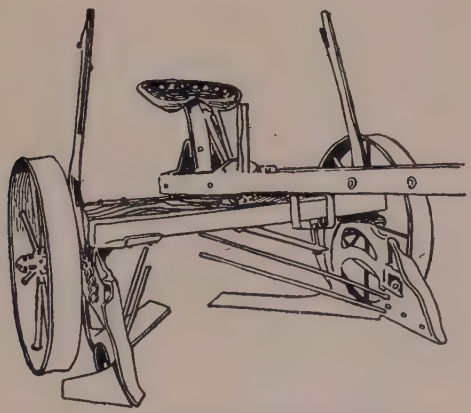

FIG. 22.—Modern type of bean-harvester.

ries shatter most readily of any varieties grown in California. Red Kidney and Bayo also drop their seed freely if allowed to mature fully. The Horse Bean, Red Mexican, Pink, Lima, Lady Washington, and small white varieties retain their seed fairly well, while Garbanzo and Cranberry shatter least of all. Before deciding to harvest beans on a large scale, the weather prediction should be consulted as the crop usually requires a period of at least five to seven days for proper curing in the field.

[1] Calif. Agr. Exp. Sta. Bull. 294, p. 49 (1921).

Only the smaller acreages are now harvested by hand pulling. The common method consists in using a bean-harvester of the type shown in Fig. 22. This implement consists of a pair of heavy knives about three and one-half feet long, mounted at an angle of about 60 degrees between two wheels and so hung that they run about two inches beneath the surface of the soil, pulling two rows at a time. These two rows of plants are left in a single windrow with most of the roots down. A man or two usually follows the harvester, forking the plants out of the dirt and putting them in small piles where they are left until the surface moisture has dried off. After a few hours, these small piles are bunched together to cure for three to five days, depending somewhat on the weather. This method of curing toughens the pods to prevent shattering, improves the vines for forage purposes, prevents the loss of leaves which would occur in rapid drying, and insures the elimination of excess moisture which would otherwise result in spoilage after stacking.

In the humid sections of the East, the cured vines are commonly stored in the barn until threshing time. In the more arid bean-growing states including Colorado, California, and New Mexico, the crop is either threshed from the stack or hauled direct from the field to the thresher.

### THRESHING (Figs. 23, 24)

Until the invention of the modern grain-thresher and bean-huller, beans were threshed from the vines by a hand-flail or tread out by beasts of burden. In these early times, it was necessary to depend on the wind for the first cleaning or else use a small man-power fan-

ning mill. At present, bean-hullers are in common use in the more intensive bean-growing regions. These machines carry two cylinders, one of which operates slowly and threshes the drier pods, while the other revolves faster and is intended to thresh the greener pods. When grain-threshers are used it is important that part of the concaves be removed and the speed of the cylinders so regulated as to avoid shattering the seed. Bean-threshers with a capacity to handle 100 to

FIG. 23.—Wooden roller used to thresh beans in some sections of the semi-arid Southwest.

2,500 bags a day are available. A combined harvester and thresher has recently appeared on the market. This machine is motor-driven, picks up the cured vines from the windrow and threshes the crop while in motion. In the semi-arid Southwest a threshing floor is prepared by leveling an area of adobe ground. The harvested vines are placed in a thick layer and the beans tread out by unshod horses or mules. After threshing, the vines are forked off and successive layers replaced until several hundredweight of threshed beans have accumulated.

While the average yield of common field beans during

recent years ranges from 10 to 15 bushels to the acre, yields of 20 to 25 bushels are not uncommon. With most varieties, the proportion of grain to straw is approximately 1 to 1, the proportion of grain being usually somewhat lower in kidney than in pea and medium varieties.

### STORAGE

More than 75 per cent of the bean crop is usually disposed of by the grower during the months of October, November, and December. In years of large crop and low price the proportion of the crop stored until spring is larger. The fact that most farmers do not have ample storage space nor facilities for cleaning and picking the crop is in part responsible for the short storage period. If the threshed crop is properly cured and dried it can be stored safely in bags. However, in years of wet weather at harvest time, it may be necessary to provide special facilities for drying.

Well-matured and cured beans contain approximately 14 per cent moisture. Immediately after threshing they may contain as high as 18 per cent moisture for safe storage in bags. However, beans with excess moisture should be placed in bins with sticks or lath inserted to prevent heating. In extreme cases, kiln-driers are used and many of the present day elevators are equipped to provide special heat and ventilation for such emergency. Kiln-drying consists essentially of spreading wet beans in a layer three or four inches deep over artificial heat for the purpose of reducing their moisture-content to a safe-keeping percentage. Facilities for drying beans can be made available on the farm provided precautions are taken against hazards from fire. The source of heat may

be a sheet-iron stove in a tightly closed room directly beneath the beans to be dried. The beans should be spread on canvas tacked to ordinary plaster lath spread on the floor supports. Although germination will not be injured at temperatures ranging from 90° to 125° Fahrenheit, the lower temperature is preferable in order to avoid cracking and shriveling of the seed.

The loss in weight of beans from the time they leave the thresher until they are shipped from the elevator

FIG. 24.—Threshing beans in the field in California.

depends principally on their initial moisture-content and the amount of foreign matter, broken and split seed, and admixture of types present. Shrinkage from the removal of "pick" in the cleaning and picking process averages about 5 per cent. Loss in weight from moisture evaporation is usually higher in the humid regions such as Michigan and New York than it is in the drier climates. This shrinkage is estimated to average from one-half to one per cent a month for the first eight months, the greater part of this occurring during the first month. Pinto beans usually contain less moisture than the com-

mon varieties grown in the East and accordingly they undergo less shrinkage. No difference in shrinkage rate has been observed between the different varieties stored under identical conditions. After the crop has been properly dried, cleaned, and picked, it should be stored under relatively cool well-ventilated conditions to avoid possible infestation and loss from the bean weevil.

# CHAPTER XII

## *MARKETING*

Before the development of automatic bean-cleaning and picking machinery, bean marketing was a relatively simple business governed by the grower and his ability to produce and merchandise a marketable product. Large-scale production has made it not only possible but necessary to utilize mechanical devices in preparing beans for market. The modern bean elevator as a facility for preparing this crop for market is too little understood and appreciated by both grower and consumer. There are at present something like 500 bean elevators in the two states of Michigan and New York alone, equipped to clean, screen, pick, polish, and otherwise handle the crop. This equipment represents a capital investment of several millions of dollars.

Owing to the non-perishable nature of dry beans and the diversity of forms demanded by the trade, they are merchandised in nearly all markets of the world and at all seasons of the year. Among the various classes of foreign extraction in our population, each has its particular preference for beans of a given type and quality. Foreign trade in beans is reciprocal and merits a more complete understanding on the part of those concerned in production as well as in marketing.

### PREPARATION FOR MARKET

Beans delivered by the thresher contain much trash

and broken and discolored seed. Cost of production has been greatly reduced by the development and constant improvement of machinery for the automatic removal of these defects. In commercial production, cleaning and picking operations are the proper function of dealers who operate elevators at points convenient to railroads.

*Function of elevator*

While beans were originally bought on the "flat" basis at a stipulated price a bushel or pound in uncleaned and unpicked form, nearly all of the commercial crop in the eastern states is now bought on the hand-picked basis. In the West the crop is bought from the growers mainly on the recleaned basis. The beans are delivered at the elevator in burlap sacks just as they came from the thresher. These are emptied into a receiving hopper from which they are elevated to a cleaning mill which removes, by means of a heavy air blast, nearly all of the split beans, dirt, and chaff (Fig. 25). The resulting recleaned beans are then weighed to determine the recleaned or delivered weight.

When bought on the hand-picked basis as in the East, a three- or four-pound sample is taken and carefully picked of all defects to determine the percentage of "pick." This pick consists of all discolored and broken beans, beans of other types, and dirt and stones not removed by the cleaning mill. While the average pick ranges from 2 to 5 per cent by weight, it may be much higher in years of wet weather at harvest times. White varieties, because of a greater tendency to discolor, usually average a higher pick than colored varieties. After deducting the total weight of pick from the total

recleaned weight, the gross value of the load is reckoned according to the prevailing market price. Subsequent to this, a further deduction of usually 5 cents a pound for the total weight of pick is made in reckoning the net price to the grower.

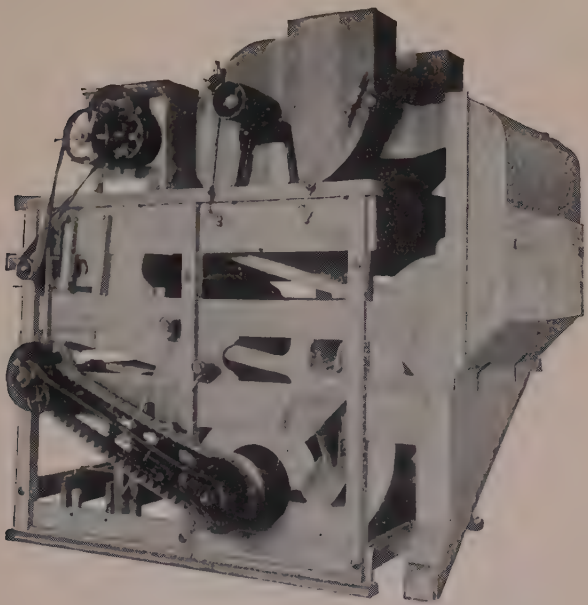

FIG. 25.—A modern bean cleaning mill.

*Price determination*

The discussion in the last paragraph indicates the usual procedure in determining the price paid the grower for the beans delivered at the elevator. For convenience, some buyers make use of a printed price schedule from which they read off directly the price a hundredweight

to be paid the grower according to the prevailing market price and the percentage of "pick" in his load. In Michigan, this price schedule has been known as the Reardon Schedule. For example, if the buying price is $10 a cwt. and the "pick" is found, by test, to be 5 pounds or 5 per cent, the net price to the grower will be $9.25 a cwt. The deduction of 75 cents represents 5 pounds of beans at 10 cents a pound plus a charge of 5 cents a pound for removing the 5 pounds of "pick." It is customary for the dealer to retain the cull beans. These are in turn sold to the grower at a nominal price to be used as hog or sheep feed.

*Picking*

After recleaning, beans are put over mechanical pickers for the removal of split and misshaped seed and foreign material. These pickers are of two principal types, the older consisting of an inclined endless belt over which the beans are fed from a hopper. By this arrangement, the good beans roll down and off the belt at once while the foreign matter and split beans adhere and are carried to another exit. A more expensive and more complex type is known as the roll-picker, various modifications of which are now available (Figs. 26, 27). It consists essentially of a series of rubber rolls, operating in pairs, and set at an incline so that the round beans roll down and off while defective seed and foreign material are caught and carried between the rolls.

Neither type of picker, however, is sensitive enough to remove discolored seed. The latter necessitates hand labor as a final step in the picking process (Fig. 28). Women are employed almost exclusively for such work as they have been found more nimble-fingered and effi-

cient than men. They are paid usually either by the day or by the pound of pick removed, the rate in the latter case varying from 5 to 8 cents a pound, depending on the kind of beans being picked. In the drier regions of the West and Southwest, hand picking is limited almost entirely to white beans and in normal years it

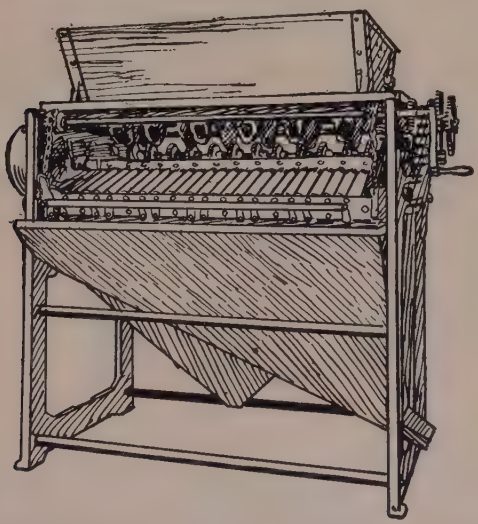

FIG. 26.—Rubber roll type of automatic bean-picker.

is necessary to hand-pick only a very small percentage of the total crop.

*Polishing*

Although polishing is not a necessary process in preparing all beans for market, it is highly advisable for white beans which have been discolored by weathering in wet seasons. Polishing removes the surface dis-

coloration and gives the seed-coat a glossy appearance. Two types of polishing machines are available. One

FIG. 27.—Improved type of automatic roll bean-picker.

consists of a set of revolving dry brushes, while the other makes use of either dry or moist sawdust in which the beans are agitated between series of hollow revolving cylinders. After polishing, an additional wind blast or aspirator is necessary to remove the fine dust particles left on the surface of the beans. Hendry[1] has classified beans according to their susceptibility to polishing as

[1]Calif. Agr. Exp. Sta. Bull. 294, p. 52 (1921).

follows: "Susceptible of high polish: Lima, Red Mexican, French White, Cranberry, Bayo, Small White, Blue Pod; susceptible of medium polish: Lady Washington, Red Kidney, Pink, Henderson Bush, Spotted Red Mexican; susceptible of dull polish: Tepary, Blackeye, Horse Bean, Garbanzo."

*Containers*

Beans are almost universally shipped in burlap sacks

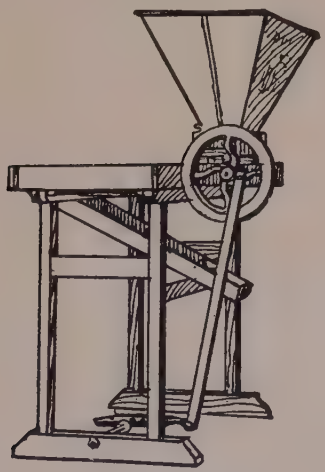

FIG. 28.—Common type of hand-picking machine.

of 100 pounds net capacity (Fig. 29). Formerly, the western crop was put up in eighty-pound sacks. The stencil commonly borne by the shipping bags now in use includes the words "100 Lbs. Net When Packed" and at the bottom "Standard Railroad Bean Bag." The type of beans contained in the package and the name

of the state in which the beans originated are also usually given on the bag. Although the legal weight a bushel in most states is sixty pounds, market price quotations are generally on the hundredweight basis. The standard carload of beans contains 400 sacks. In attempting to stimulate a greater market for dry beans, a few dealers have put up the commodity in two-pound and in five-pound cloth bags and paper cartons. These may in time become popular among the grocery chain stores but so far they have not been handled on a large scale.

*Grades and grading*

The advantages of established grades in merchandising beans have been appreciated by marketing organizations for many years. Accordingly, each of the leading bean-growing states of California, Michigan, and New York have administered an official inspection service using a system of grades adapted to the types grown and conditions obtaining in these respective states. In California, arbitrary grades are established each year by the Grain Inspection Department of the Grain Trade Association of San Francisco. These grades are based on samples collected in different parts of the state and are representative of the crop for that season. The designations F. A. Q. No. 1 and F. A. Q. No. 2 refer to fair average quality as determined by the above association. In addition, Garbanzos, Small Whites, and Lady Washingtons are graded into various sizes of seed. In fact, it is general practice, when white beans vary considerably in size, to screen them into uniform sizes to improve their market appearance. In Michigan and New York, the official grades have been designated mainly as "choice

hand picked," a particular grade being determined on the basis of color, brightness, soundness, uniformity of size, and percentage of discolored and split beans contained. Dry beans are usually designated as those con-

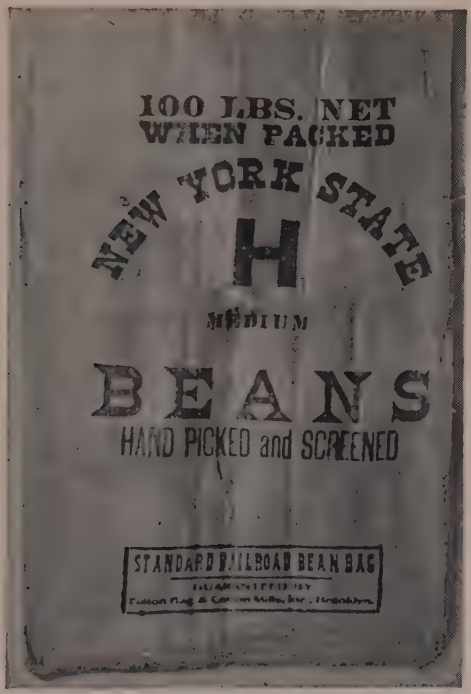


FIG. 29.—Standard bean bag used in shipping beans (capacity 100 pounds).

taining a maximum of not to exceed 17 per cent of moisture. Official inspection certificates, certifying as to grade of each car of beans shipped, are issued by the agency in charge within each state.

## *U. S. GRADE REQUIREMENTS FOR BEANS*

Grades.—The Classes Pea Beans, Red Kidney, Dark Red Kidney, White Kidney, Medium White, Marrow, Yelloweye, Brown Swedish, Great Northern, Pinto, Small White, Large White, Pink, California Red, Bayo, Cranberry and Blackeye each shall be divided into three numerical grades and sample grade and the Classes Lima and Baby Lima each into two numerical grades and sample grade, the requirements of which shall be as follows:

| U. S. Grade | Class and General Appearance | Maximum Limits of Splits, Damage, Other Beans, and Foreign Material | | |
|---|---|---|---|---|
| | | Total | Other Beans[1] | Foreign Material |
| | Class I, Pea Beans | Per cent | Per cent | Per cent |
| No. 1.. | Well screened and good natural color and appearance | 1.5 | 0.0 | Tr.[2] |
| No. 2.. | Well screened and may be slightly off color..... | 3.0 | 0.1 | 0.1 |
| No. 3.. | May be dull or of poor color | 5.0 | 0.5 | 0.5 |
| Sample grade | (See page 147) | | | |
| | Class II, Red Kidney<br>Class III, Dark Red Kidney | | | |
| No. 1.. | Well screened and good natural color and appearance | 2.0 | 0.0 | Tr.[2] |
| No. 2.. | Well screened and may be slightly off color..... | 4.0 | 0.2 | 0.2 |
| No. 3.. | May be dull or of poor color | 6.0 | 0.5 | 0.5 |
| Sample grade | (See page 147) | | | |

(See page 146.)

[2] TRACE, (Tr.), as applied to "foreign material" in grade No. 1 of the Classes Pea Beans, Red Kidney Beans, and Dark Red Kidney Beans shall not exceed 1/100 of one per cent, and shall not include any stones which can be detected by methods of sampling approved by the Chief of the Bureau.

GRADE REQUIREMENTS FOR BEANS—*Continued*

| U. S. Grade | Class and General Appearance | Maximum Limits of Splits, Damage, Other Beans, and Foreign Material | | |
|---|---|---|---|---|
| | | Total | Other Beans[1] | Foreign Material |
| | Class, IV, White Kidney<br>Class V, Medium White<br>Class VI, Marrow<br>Class VII, Yelloweye<br>Class VIII, Brown Swedish | Per cent | Per cent | Per cent |
| No. 1.. | Well screened and good natural color and appearance | 2.0 | 0.1 | 0.1 |
| No. 2.. | Well screened and may be slightly off color..... | 4.0 | 0.2 | 0.2 |
| No. 3.. | May be dull or of poor color | 6.0 | 0.5 | 0.5 |
| Sample grade | (See page 147) | | | |
| | Class IX, Great Northern | | | |
| No. 1.. | Well screened and good natural color and appearance | 2.0 | 0.3 | 0.3 |
| No. 2.. | Well screened and may be slightly off color..... | 4.0 | 0.6 | 0.6 |
| No. 3.. | May be dull or of poor color | 6.0 | 1.0 | 1.0 |
| Sample grade | (See page 147) | | | |
| | Class X, Pinto | | | |
| No. 1.. | Well screened and good natural color and appearance | 4.5 | 0.5 | 0.5 |
| No. 2.. | Well screened and may be slightly off color..... | 7.0 | 1.0 | 1.0 |
| No. 3.. | May be dull or of poor color | 10.0 | 1.5 | 1.5 |
| Sample grade | (See page 147) | | | |

[1] (See page 146.)

GRADE REQUIREMENTS FOR BEANS—*Continued*

| U. S. Grade | Class and General Appearance | Maximum Limits of Splits, Damage, Other Beans and Foreign Material | | | |
|---|---|---|---|---|---|
| | | Total | Damage | Other Beans* | Foreign Material |
| | | Per cent | Per cent | Per cent | Per cent |
| | Class XI, Small White | | | | |
| No. 1.. | Well screened and good natural color and appearance..... | 1.5 | 1.0 | 0.3 | 0.3 |
| No. 2.. | Well screened and may be slightly off color..... | 3.0 | 2.0 | 0.5 | 0.5 |
| No. 3.. | May be dull or of poor color.... | 5.0 | 3.0 | 1.0 | 1.0 |
| Sample grade | (See page 147) | | | | |
| | Class XII, Large White<br>Class XIII, Pink<br>Class XIV, California Red<br>Class XV, Bayo<br>Class XVI, Cranberry<br>Class XVII, Blackeye | | | | |
| No. 1.. | Well screened and good natural color and appearance..... | 2.0 | 1.0 | 0.5 | 0.5 |
| No. 2.. | Well screened and may be slightly off color..... | 4.0 | 2.0 | 1.0 | 1.0 |
| No. 3.. | May be dull or of poor color.... | 6.0 | 3.0 | 1.5 | 1.5 |
| Sample grade | (See page 147) | | | | |

[1] OTHER BEANS.—An allowance of 2% in grade 1, 3% in grade 2, and 5% in grade 3, shall be made for "Other Beans" in Classes I to XVII, inclusive, except Class VII, Yelloweye Beans, in excess of the allowance of "total splits, damage, other beans, and foreign material," provided such additional "Other Beans" are similar in shape and size to and the color blends with that of the beans in the sample being graded. This allowance shall apply also to the so-called "Sports" in Class II, Red Kidney Beans; and Class III, Dark Red Kidney Beans. In Class VII, Yelloweye Beans, the total allowance of white beans of a size and shape similar to that of Yelloweyes may be 10% in grade 1, 15% in grade 2, and 20% in grade 3.

GRADE REQUIREMENTS FOR BEANS—*Continued*

| U. S. Grade | Class and General Appearance | Blistered and Wrinkled Beans | Skinned and Broken Beans | Splits | Damaged Beans and Foreign Material | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Total | Worm Damage | Other Damage | Foreign Material | |
| | | | | | | | | Total | Stones |
| | Class XVIII, Lima Class XIX, Baby Lima | % | % | % | % | % | % | % | % |
| No. 1.. | Well screened* and of good natural color and appearance..... | 2.5 | 2.5 | 2.0 | 1.0 | 0.5 | 0.5 | 0.3 | 0.1 |
| No. 2.. | Well screened‡ and may be slightly off color..... | 5.0 | 5.0 | 3.0 | 2.0 | 1.0 | 1.0 | 0.5† | 0.2 |
| Sample grade | (See below) | | | | | | | | |

*NO. 1 LIMA BEANS shall be of a size such that not more than 40% will pass through a 32/64" round hole screen. This size requirement shall be supplemental to that of "well screened" as defined below.

‡NO. 2 LIMA BEANS shall be of a size such that not more than 10% will pass through a 24/64" round hole screen and not more than 45% through a 28/64" round hole screen. This size requirement shall be supplemental to that of "well screened" as defined below.

†NO. 2 BABY LIMAS may contain not more than 1% of foreign material provided the total of damaged beans and foreign material does not exceed 2%.

SAMPLE GRADE.—Beans of any Class I to XIX, inclusive, which do not meet the requirements for any of the numerical grades applicable to the respective classes or which contain over 17% moisture, or have any commercially objectionable odor, or are heating, or weevily, or otherwise of distinctly low quality.

WELL SCREENED.—As applied to the general appearance of beans, shall mean that the beans are practically free from such small, shrivelled, undeveloped, split and broken beans and foreign material as can be readily removed in the ordinary processes of milling or screening.

The United States Department of Agriculture, through its Bureau of Agricultural Economics, established recommended standards for the grading and marketing of beans effective September 1, 1926. The general adoption of these standards should promote uniform grading and facilitate marketing throughout the United States. These standards are the result of careful study of existing grades and conditions and comprehend every commercially imported type found in the markets.

Federal bean inspection is authorized by a clause in the annual Appropriation Act for the Department of Agriculture. The general plan for conducting this service provides for the employment of federal bean inspectors at shipping points and at important terminal markets under coöperative agreements between the Bureau of Agricultural Economics and organizations such as state departments of agriculture, commercial exchanges, and dealers' and growers' associations. Under these agreements, persons who possess the necessary qualifications are trained and licensed as federal bean inspectors and their work supervised by the Bureau during the life of the license.

### MARKETING

Although dry beans are bought and sold in consumer markets during every month of the year, it is estimated that no less than 75 per cent of the crop is normally out of the growers' hands by January 1st. This will vary from year to year depending somewhat on the size of the available crop. In general, the bulk of buying at the shipping points occurs between October 1st and December 15th. This demand is relatively light from

December 15th to February 1st and again increases from February 1st to about May 15th after which most of the crop has left the country shipping points.

According to figures published by the United States Department of Agriculture,[1] the average farm price a bushel showed no consistent variation from month to month for the years 1910 to 1923 inclusive. This indicates that there is at least no disadvantage in the usual practice of marketing the bulk of the crop from the farm during the fall and early winter months.

*Marketing organizations*

The necessity of a large capital investment in bean-cleaning and picking machinery and the importance of operating and maintaining this equipment efficiently has exerted considerable influence on the type of organization handling the crop. Comparatively few organizations operating plants at many shipping points in each of the bean-producing states handle most of the crop. Only a few are organizations of growers and these few are located mainly in the western states. In New York, several of the dealers are federated into the New York State Bean Shippers' Association. This association maintains a permanent secretary who administers the official shipping point inspection service and issues certificates as to bean grades. Other examples of bean marketing organizations are California Bean Growers' Association, Rocky Mountain Bean Dealers' Association, Michigan Elevator Exchange, The Denver Elevators, and the Michigan Bean Jobbers' Association.

[1]Monthly Farm Prices of Beans (dry), 1910-1923. U. S. Dept. Agr. Weather, Crops & Markets, Vol. 4, No. 26 (Dec. 29, 1923).

*Bean markets*

The largest bean markets in the United States are New York, Boston, Detroit, Denver, San Francisco and New Orleans. New York is not only the greatest consuming center but also ranks high as a port of entry and of export. Oriental beans enter this country mainly at San Francisco. A large volume of the colored varieties produced in the western states are exported from New Orleans. Although a few White Kidney beans are marketed generally, the principal demand for this type is the Italian trade in New York City. Yelloweye beans are consumed mostly in New England, Boston and Providence being the principal markets. Small white varieties are probably more popular than either the large whites or any of the colored sorts. An appreciable percentage of these are canned with pork and marketed as pork and beans. Although the production of white marrows is increasing, the trade is unwilling to absorb more than a small volume of these at present. Only a few Red Kidneys are marketed as dry beans in the United States although an increasing volume is being canned for the pork and bean trade. Such varieties as Pinto, Pinks, Cranberrys, and Blackeyes are marketed largely in the southern states. The trade in Great Northern variety is said to be developing rapidly in the Middle West.

*Foreign trade*

In comparison with an average annual domestic production of about 14,000,000 bushels, foreign trade ranges from about 500,000 to 4,000,000 bushels from year to year. On the average, importations exceed exportations. The domestic production and foreign trade in beans of

the United States for the decade 1915 to 1924 are indicated in figures furnished by the Bureau of Foreign and Domestic Commerce in Table XIX.

TABLE XIX

BEANS (DRIED): U. S. IMPORTS, DOMESTIC EXPORTS, RE-EXOPTS, NET IMPORTS, AND PRODUCTION, 1915-1924

| Year Ending Dec. 31 | Year Beginning July 1 | | | | | |
|---|---|---|---|---|---|---|
| | Production | General Imports | Domestic Exports | Re-exports | Net Exports or Imports | Production — Net Exports or % Net Imports |
| | 1,000 bushels | 1,000 bushels | 1,000 bushels | 1,000 bushels | 1,000 bushels | 1,000 bushels |
| 1915 | 10,321 | 663 | 1,760 | 181 | —1,278 | 9,043 |
| 1916 | 10,715 | 3,748 | 2,165 | 509 | +1,074 | 11,789 |
| 1917 | 16,046 | 4,146 | 1,517 | 742 | +1,887 | 17,933 |
| 1918 | 17,397 | 4,016 | 4,489 | 1,668 | —2,141 | 15,256 |
| 1919 | 13,349 | 3,806 | 1,992 | 2,040 | — 226 | 13,122 |
| 1920 | 9,185 | 824 | 1,216 | 460 | — 852 | 8,333 |
| 1921 | 9,150 | 520 | 1,100 | 214 | — 794 | 8,356 |
| 1922 | 12,793 | 2,623 | 672 | 381 | +1,570 | 14,363 |
| 1923 | 16,004 | 886 | 695 | 346 | — 155 | 15,849 |
| 1924 | 13,327 | 1,421 | 549 | 265 | + 607 | 13,934 |

Compiled from Foreign Commerce and Navigation of the U. S., 1915-1918, and Monthly Summaries of Foreign Commerce of the U. S. June issues, 1921-1924. Production from Division of Crop and Livestock Estimates, U. S. Dept. Agr.

By far the greater part of the import beans is small white Kotenashi from Japan. A somewhat larger variety known as Otenashi and the Nagauzura, a red speckled kidney bean, are also imported in small quantity from Japan and Manchuria. Being similar to white pea beans, the Japanese Kotenashi is of some influence in competition with native beans in certain years. Under the Federal Tariff Act of 1913, the protective tax on foreign

beans was 25 cents a bushel. This served as a source of revenue rather than as a protection, since it did not exclude foreign beans in any true sense. The Tariff Act of 1922, levying a duty of 1¾ cents a pound or $1.05 a bushel of 60 pounds has undoubtedly been a greater influence on the domestic bean market. Second to Japan, bean imports originate mainly in Rumania, Mexico, Canada, Hungary, Italy, Belgium, Netherlands, Chile, and Madagascar. Except those from Mexico and Madagascar, these types are similar to those produced in the United States but they do not effect the markets appreciably. Mexico sends Garbanzos or chick-peas, while a type of lima inferior to native sorts is imported from Madagascar. From two-thirds to three-fourths of the total export trade is of Red Kidneys sent to Cuba. The other principal countries concerned in exports of beans are Canada, the Central American countries, Mexico and Russia. Colored varieties including those grown in California are popular among the Spanish-speaking peoples of the West Indies and Central America.

## CHAPTER XIII

## *QUALITY OF BEANS*

Dry-shell beans are grown primarily for human food to be prepared and served mainly as baked beans or as bean soup. In preparation for baking, they are first boiled in water seasoned with salt in order to soften them and increase their digestibility. Beans canned as pork and beans are now one of the most popular forms in which they are marketed and this furnishes one of the most extensive outlets for the crop. Cull beans, a by-product of the cleaning and picking process, and bean straw furnish valuable and nutritious feed for various classes of live-stock.

### FOOD VALUE OF BEANS

The value of beans as food is measured in terms of nutritive qualities, digestibility, and palatability. Their composition and caloric value are compared with other common foods in Table XX.

These data indicate that as a source of protein beans compare closely with lean beef and that they rank high as a source of body-heat-producing substance. At normal prices, the protein in beans is cheaper than that in meat, but it has been found in feeding tests to be less digestible. Beans are classed among the so-called hearty foods and should be eaten in moderation especially by persons of sedentary habits. In feeding experiments

TABLE XX

COMPOSITION OF NAVY BEANS COMPARED WITH OTHER FOODS [1]

| Food | Per cent of | | | | | Fuel Value per Pound in Calories |
|---|---|---|---|---|---|---|
| | Water | Protein | Fat | Carbo-hydrates | Ash | |
| Navy beans | 12.6 | 22.5 | 1.8 | 59.6 | 3.5 | 1,605 |
| Potatoes... | 78.3 | 2.2 | 0.1 | 18.4 | 1.0 | 385 |
| Lean beef... | 70.0 | 21.3 | 7.9 | .... | 1.1 | 730 |
| Milk..... | 87.0 | 3.3 | 4.4 | 5.0 | 0.7 | 325 |
| Eggs..... | 73.7 | 14.8 | 10.5 | .... | 1.0 | 720 |

with rats, Jones [2] of the United States Bureau of Chemistry tested the nutritive qualities and the digestibility of the protein of navy beans. Among the constituents of protein are what he terms "the nutritionally essential amino acids" such as lysine, tryptophane, and cystine. Quoting Jones, "The results of experiments conducted in this laboratory and elsewhere have shown that the proteins of the common white navy bean will not satisfactorily promote growth in young animals. Fed either the isolated proteins or the raw ground bean as the sole source of protein in a diet adequate with respect to the other dietary factors, rats decline in weight and live but a relatively short time." Further, "The defective properties of the navy bean proteins are due to a form of indigestibility which can be corrected by cooking, and also to a lack of the available cystine. Digestion experi-

[1] Data taken from "Beans, Peas and Other Legumes as Food." U. S. Dept. Agr. Farmers' Bull. 121 (1900).

[2] Jones, D. Breese. "The Chemistry of Proteins and Its Relation to Nutrition." The American Jour. of Public Health, Vol. XV, No. 11, Nov., 1925.

ments . . . have shown that phaseolin, the chief protein of the navy bean, is more digestible after it has been cooked. Similar studies made on the proteins of the lima bean, adsuki bean, mung bean, cow pea, and the lentil showed that they also have the same defective nutritive properties."

### MARKET VALUE OF BEANS

From the standpoint of marketability, no single factor is more important than appearance of the seed. Uniformity, color, brightness or luster, soundness, and freedom from defects and mixture play a distinct part in their influence on appearance of the market product.

### JUDGING MARKET AND SEED VALUE

Dry field beans are now commonly included in most public exhibitions of field crop seeds in the principal bean-producing states. On account of the numerous types and varieties grown, a knowledge of characters whereby these types and varieties are distinguished is important. It is equally important that factors which determine the seed and market value of dry beans be considered. A score-card with a brief discussion of these factors is, therefore, of instructional value. Beans are best exhibited as plate, quart, two-quart, or peck samples depending on the type and purpose of the exhibit.

*Score-card for dry-shell beans*

| | |
|---|---|
| Uniformity (of all physical characters) | 20 |
| Freedom from defects (disease, insect or mechanical) | 25 |
| Condition (as to soundness, maturity, and general appearance) | 20 |

| | |
|---|---|
| Color (typical for the variety) | 15 |
| Size (true to type) | 10 |
| Shape (true to type) | 10 |
| | 100 |

*Explanation of score-card*

*Uniformity.*—As a matter of merchandizing, nothing is more important than appearance. This means that the sample should be uniform in all characters such as size, shape, color of seed and condition of seed-coat.

*Freedom from defects* (disease, insect, mechanical).—Such diseases as anthracnose (pod-spot) and blight are common and detract from appearance as well as culinary and seed value. Special care is necessary in observing these diseases on colored beans. Weevil injury is more common on old seed. Split beans may be due to too close threshing, to excess drying, or to rough handling of old seed.

*Condition.*—This refers largely to seed condition. Beans more than one year old will be brittle rather than waxy as determined by biting. The germ should be pliable, rather than dried and shrunken away from the cotyledon. Seed not properly matured may show wrinkled seed-coat or shrunken germ. Old seed (undesirable for seed) can be distinguished by (1) degree of hardness, (2) condition of germ, and (3) appearance of seed-coat. Old seed is likely to be shiny and darker in color than new seed.

*Color.*—White beans are preferred on most eastern markets. Red, yelloweyed, black or mottled varieties are popular only on a few special markets, i. e. Red Kidney in Cuba, Porto Rico and Mexico, Yelloweye in Boston. White varieties should be pure white, bright

and free from dark streaks or venation. Red varieties should be bright, light red or almost pink in new seed. Yelloweyes should show the yellow small in area and closely confined about the hilum (seed-scar) in contrast to old-fashioned yelloweyes in which the yellowing is more mottled and scattered.

*Size.*—Most field varieties classify as either pea, medium, marrow or kidney type. Navy is a name rather generally applied to both pea and medium types. Pea beans should be smallest, medium beans slightly larger, marrow beans still larger and kidney beans largest. Large size within the type is especially desirable.

*Shape.*—This is of equal importance with size. A round or plump shape is especially desirable in pea and marrow beans. Medium and kidney beans are typically more flattened. Kidney is the only one of the four types which is typically reniform. The thickness of a medium bean is typically less than half its length while in a marrow bean it is more than half its length. A medium bean is not only flatter than the pea bean but frequently exhibits seeds more or less square-ended.

### FACTORS AFFECTING QUALITY

Whether a given lot of beans shall be adjudged high or low quality naturally depends much on the specific use for which it is intended. The quality requirements of beans for seed, for canning, and for the general market are somewhat distinct. Beans for the pork-and-bean or baked bean trade must first of all be clean, free from admixture with odd types, and uniform in respect to culinary quality. Seed beans should be uniform in type, free from seed-borne diseases, and of high germination. Appearance is the paramount factor in beans for the

general market. Age of seed, and storage temperature greatly influence quality in beans for whatever purpose they are intended. Old seed usually can be distinguished from new by its darker, shinier, tougher seed-coat. It is not only less viable as seed but also less digestible as food on account of its increased toughness due to a thickening of the cell-walls. In old seed, the cotyledon is brittle, darker in color, and the germ is likely to be contracted away from its surrounding tissue. Storage at low temperatures ranging from 35° to 50° Fahrenheit is a material aid in preserving both seed and culinary quality. McCall[1], an experienced canner, has stated that "Beans are at the zenith of excellence within one month after they have ripened and have naturally attained a normal moisture content of 16 per cent without having been exposed to rains or excessive dampness after they were fully ripened. It is at this time that the physical texture of the bean is in that state that is most esteemed by epicures."

### COMPARISON OF VARIETIES

Jaffa and Albro[2] analyzed the seed, straw, and pods of the sixteen varieties and types grown in California and found that the protein-content of the seed was consistently lower than that reported by most other investigators. They attributed this to the climatic influence peculiar to California which has been previously shown to produce the same effect on the protein-content of California wheat. They also noted a considerable dif-

[1]McCall, J. W. "Beans Boast Ancient Line: Fed Man in Bronze Age." The Bean Bag, Vol. 8, No. 7, Dec., 1925.

[2]Jaffa, M. E., and Albro, F. W. "Composition of California Bean Varieties." Calif. Exp. Sta. Bull. 294, pp. 58-60 (1921).

ference between varieties in respect to percentage composition. Cooking tests with several varieties of Phaseolus were made at the Ontario Agricultural College.[1] The Marrowfat variety was rated low because of a mussy appearance attributed to its tender skin. On the contrary, the Red Kidney and the Large White Haricot were classed high because they retained their form well. In flavor, the White Wonder, Pearce's Improved Tree, and Schoefield Pea were the three best while the Marrowfat and the Large White Haricot were the poorest. Colored varieties, such as Red Kidney and Black Turtle Soup are generally unpopular in North America because of prejudice against their color and in spite of their excellent flavor. Pea and medium varieties are used most for canning, although Red Kidneys and a few Yelloweyes are canned to a lesser extent. The Tepary is said to be unpopular because of its low quality and the difficulty of cooking.

### CULLS AND STRAW FOR LIVE-STOCK

Cull beans, which are a by-product of grading, have a high feeding value for certain types of livestock. They contain about twice as much protein as corn and oats and about the same amount as gluten feed. In nitrogen-free extract, they compare favorably with oats and gluten feed and contain about two-thirds as much as corn. They are not well adapted for horses and cattle because these animals cannot separate the dirt and gravel from the culls. However, they are excellent for sheep, and hogs thrive on moderate rations of cooked cull beans. A ration including 25 pounds of cull beans was compared with one containing 12½ pounds of cottonseed meal in

[1]Ont. Agr. Exp. Sta. Bull. 232.

a feeding test with dairy cows at the Michigan Experiment Station[1] during the winter of 1923-1924. Results were measured in terms of milk flow, butter-fat, and weight gain for the thirty-day period of the test. They concluded that cull beans have a feeding value for dairy cows equal to nearly half that of cottonseed meal and that their palatability depends largely on the other feeds used in the grain ration. Titus [2] tested the feeding value of Pinto bean culls fed to steers and concluded that they could not be fed in amounts greater than 4 pounds a day to steers of 500 to 600 pounds live weight without causing them to scour. Cooking seemed to reduce this scouring effect somewhat.

Bean straw compares favorably with the straw of

TABLE XXI

DIGESTIBLE NUTRIENTS IN BEAN STRAW AND OTHER COMMON ROUGHAGES[3]

| Roughage | Percentage of Total Dry Matter | Pounds of Digestible Nutrients | | | Nutritive Ratio |
|---|---|---|---|---|---|
| | | Percentage of Protein | Percentage of Carbohydrates | Percentage of Protein and Carbohydrates | |
| Bean straw.. | 95.00 | 3.60 | 39.70 | 43.30 | 1:11.0 |
| Timothy hay | 87.00 | 2.80 | 46.50 | 49.30 | 1:16.6 |
| Corn stover.. | 60.00 | 1.70 | 34.00 | 35.70 | 1:19.9 |
| Oat straw... | 91.00 | 1.20 | 40.40 | 41.60 | 1:33.6 |

[1]Reed, O. E., and Burnett, J. E. "Feeding Cull Beans to Dairy Cows." Mich. Agr. Exp. Sta. Quart. Bull., Vol. 7, No. 1 (August, 1924).

[2]Titus, Harry W. "Nutritive Properties of Pinto Beans and Pinto Bean Straw and Their Use as Feed for Cattle." New Mex. Agr. Exp. Sta. Bull. 143 (Tech.) (1924).

[3]Table taken from "Commercial Bean Growning in New York." Cornell Agr. Exp. Sta. Bull. 210 (1903).

cereal grains for stock feeding and on account of its laxative properties it is usually fed in combination with other roughage. A comparison with other common roughage is shown in Table XXI.

The efficiency of sheep as consumers of bean culls and straw is evidenced by the fact that many farmers in the bean-growing regions depend largely on sheep as a means of utilizing these by-products.

## CHAPTER XIV

### *BREEDING AND IMPROVEMENT*

Few vegetables lend themselves better to breeding and improvement because of their quick growth and convenient characters than the common bean. Distinction should be made, however, between breeding and improvement as these terms are used here. Improvement, as the term signifies, has for its definite aim the amelioration of some economic character such as habit of growth, time of maturity, yield, disease-resistance, or type of pod. Breeding may or may not aim directly at improvement but, as is often true, may design merely to determine the mode of inheritance of certain measurable characters according to mendelian ratios. Hybridization involves the sexual combination, recombination and segregation of characters, while subsequent to hybridization, selection involves merely the isolation of certain individual plants possessing characters which it is designed to multiply and perpetuate.

There is great need for improvement, by whatever means are available, of most commercial seed bean stocks. This is particularly true of common field and of common garden varieties. Many of these stand in need of breeding for disease-resistance, for improved quality and of selection for increased uniformity of seed type, and yield.

Barring a few special cases, bean growers have devoted very little attention to the improvement of this crop

by the use of hybridization or selection. Although breeding in its true application is properly the function of the scientist and the seed bean specialist, improvement by field and seed-plot selection merits increased interest on the part of growers. Comparatively few leading seedsmen are properly bean specialists. Possible explanation for this may lie in the fact that although bean breeding is not difficult, the technique involved is laborious, parent stocks are often hybrid and in need of purification, and several factors may be involved in the inheritance of the characters under study.

### IDEAL CHARACTERS

Characters and qualities sought in bean breeding vary somewhat with the kind of bean and the purpose for which it is grown. High yield and disease-resistance are always desirable. Dry-shell beans should ripen the pods uniformly, hold the pods well off the ground to avoid weathering, thresh easily and yet not shatter badly. Snap-beans for canning should reach the canning stage in a uniform condition, be comparatively free from strings, and hold the color well in processing. Snap-beans used as a fresh vegetable should be tender, of good flavor, and stringless. When grown for this purpose, it is not important that all the pods come to edible condition at the same time. Green-shell beans should be tender, of good flavor, and not difficult to shell as the latter is one of the limitations to more extensive production of this type.

### PLANT PECULIARITIES

A knowledge of the plant itself, in so far as it relates to the technique of breeding, is essential to improve-

ment work by this means. The flower is papilionaceous or of the pea-blossom type, characteristic of the legume family. This means that the flowers are most commonly, though not always, self-fertilized. The flower structure (Fig. 30) consists essentially of a minute calyx subtending the complex corolla comprising two wings, a standard and a more or less spirally twisted keel. Enclosed within the keel are the male and female organs consisting of several stamens, each with its bilobed anther sack, and a long recurved style at the base of which lies the ovary or undeveloped bean pod. On the innermost margin of the apex of the stigma are numerous stigmatic hairs which function in catching and holding the pollen-grains at the time of pollination. Normally fertilization occurs while the essential organs are still inclosed within the keel. However, it has been observed by Pearl and Surface[1] that bumblebees are capable of causing a certain amount of cross-fertilization. When the bumblebee alights on the lower petals or wings of the blossom, the weight of its body forces the long pistil out of the keel into contact with the pollen-grains carried by the bee from other blossoms. Honeybees and other common insects are said to be too light to trip the blossom petals and force out the pistil. In breeding work, when no crossing is to be tolerated, it is desirable to screen the plants against bumblebees. Mixture of types observed in varieties grown in adjacent rows under open field conditions can well be ascribed to the influence of this one insect.

The average stock of beans is a mixed population of

[1]Pearl, Raymond, and Surface, Frank M. "Studies on Bean Breeding: I. Standard Types of Yellow-Eye Beans." Maine Agr. Exp. Sta. Bull. 239 (1915).

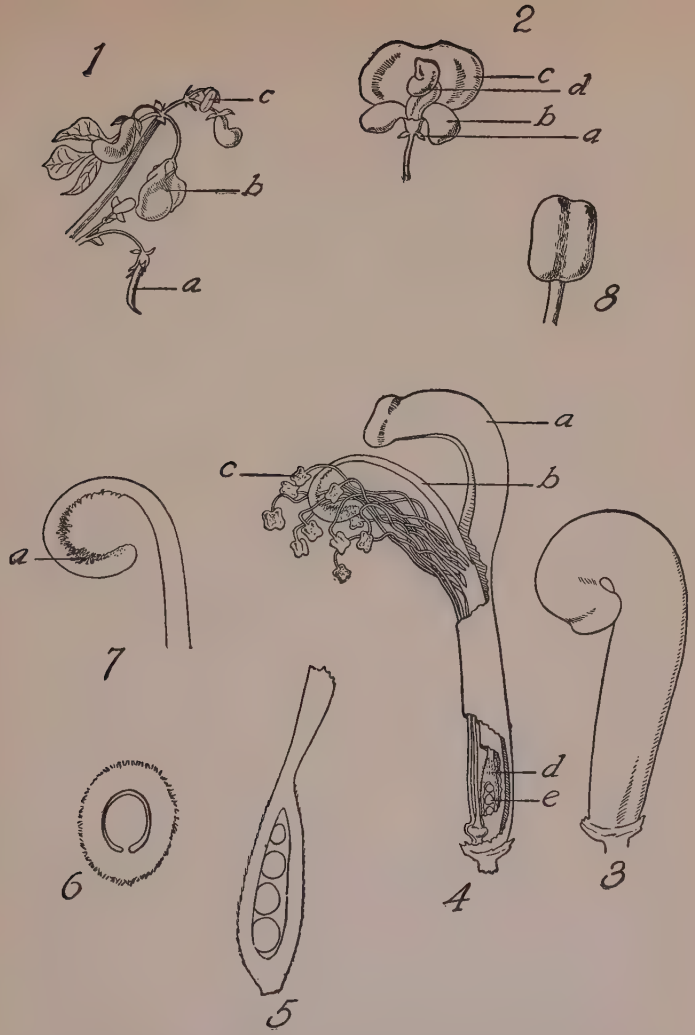


FIG. 30.—Flower structure of the bean. (1) Small branch showing: *a*, developing pod; *b*, *c*, flowers in stages of development. (2) Front view of fully opened flower: *a*, calyx; *b*, wings; *c*, standard; *d*, keel. (3) Enlarged keel. (4) Keel with outer part broken away to show: *b*, style; *c*, anther; *d*, undeveloped pod; *e*, ovary. (5), (6) Longitudinal and cross-section of pod. (7) Enlarged stigma showing: *a*, stigma hairs. (8) Anther. Size: 1, 2, natural; 3 to 8, greatly enlarged.

(From Hayes and Garber's "Breeding Crop Plants," McGraw-Hill Book Co.)

varying sizes, shapes and possibly colors of seed. Such of these variants as will breed true for the variable character isolated represent a pure line or a biotype. It was the selection of such variations or biotypes in respect to seed weight in the Princess bean which, after six years of continuous selection and study, gave rise to the pure-line theory of Johannsen.

### IMPROVEMENT BY SELECTION

It is the existence of these heritable variations, regardless of their origin, which furnishes the basis for improvement by selection. Improvement in beans by this means has in view the fixing of desirable hereditary variations already existing but the method is strictly limited in its application. New characters and qualities are not produced, but by isolating individual plants possessing desirable hereditary characters and multiplying these, improved strains can be built up and commercialized. According to Johannsen's pure-line theory, no further significant improvement or alteration beyond the average of the progeny of the original selection is possible. Continuous selection, therefore, aims merely to maintain the improvement already made and to eliminate diseased or aberrant material which may at any time occur within the stock.

There are a number of valuable heritable chance variations or mutations in beans which, once discovered and propagated, have proven of great commercial importance. Babcock and Clausen[1] report that, "Very recently mutations of great commercial value occurred in the Florida Velvet Bean, *Mucuna utilis*. The old variety

[1]Babcock, E. B., and Clausen, R. E. "Genetics in Relation to Agriculture." McGraw-Hill Book Co., New York, p. 367 (1918).

was limited to Florida and the Gulf Coast on account of lateness. About 1,000,000 acres were grown in 1915. We are informed by Piper that early varieties originated by mutation at at least three different places, the first in 1906. These resulted in the crop being adapted to the entire cotton belt and in a very rapid increase in acreage since 1915. In 1916 about 2,650,000 acres were grown and in 1917, about 6,000,000 acres." Both the Henderson Bush and the Burpee Bush varieties of lima beans were discovered as chance variations and later developed to be of immense value to the lima bean industry. Notable examples among varieties of common field beans which originated as chance variations are Michigan Robust Pea and Wells Red Kidney. The former was developed at the Michigan Agricultural College as a strain immune to mosaic found in a field of common pea beans badly affected with this disease. Due to its resistance to other serious bean diseases and to its high yield, it has largely superseded the common strains of pea beans and has been the means of preserving the industry in many sections of New York and Michigan. The Wells strain of Red Kidney notably resistant to the more common strains of anthracnose was discovered as a chance variation by a bean-grower in Wayne County, New York. This selection has proven of immense commercial value not only for its own qualities but also for its use as parent breeding stock in combining its disease-resistant qualities with other varieties.

*The seed plot*

In bean improvement work, the objectives can be accomplished better by confining the efforts to selected seed stock grown in an isolated seed-plot than otherwise.

This makes it easy to observe and record the performance of parent stocks with respect to the desired characters. Isolation, in itself, provides against contamination with disease from commercial fields and the likelihood of cross-pollination by bumblebees. Just how far the seed-plot should be removed from other fields has not been determined. Bean breeders seem to be agreed that the minimum distance should be twenty rods and more if convenient. In laying out the plot, the plants should be rather widely spaced, say three feet between rows and far enough apart in the row to allow full development of each plant and to minimize the danger of the spread of disease between plants.

Since all the progeny of a single plant tend to reproduce the hereditary characters of the parent, the individual plant should constitute the unit of selection in seed-plot work. The selection of parent plants from the commercial field for the seed-plot should be done when the foliage is in vigorous growing condition and again just before harvest. Stakes are convenient as markers which can be readily seen at the time the plants are hand-pulled in the fall. Although the specific characters used as a basis for plant selection vary with the type of beans and the primary purpose of production, general vigor, yield, freedom from disease, and time of maturity always should be given first consideration. Type of plant is important as a factor related to ease of harvest and seed production. The upright bush habit of growth is most desired in varieties grown for seed. These, in general, mature earlier and cure more easily than the vining and decumbent types. Plants which hold the pods off the ground well are in favor, affording better provision against weathering of the seed. This is espe-

cially true of white varieties grown on heavy soil in humid regions. In general, marrow and kidney beans are less viny and hold their pods higher than the pea and medium types.

Successful seed-plot work requires a definite planting plan supplemented with brief notes and careful labeling. Seed representing run-of-the-field stock from which the plant selections were made should be used in the seed-plot as a check in measuring improvement. Studies in experimental methods have shown that twenty five-hill rows replicated at least three times are sufficient for reliability of results with most, if not all, intertilled crops. Since it is desirable to measure the performance of the progeny from each selected plant, the seed-plot should include plant-to-row or plant-to-plot testing. Ordinarily, the selected plant will provide sufficient seed for one hundred or more plants which may be planted in one, two, or three plant hills according to the amount of seed available. The second year after the original selection, the progeny of those hills which reached the standard of perfection set, should be tested in multiplication plots of convenient size, again in comparison with the original commercial strain. Ample seed should be available for seeding these multiplication test plots of one-fortieth to one-twentieth acre size and replicating each strain two or three times. Where check-plots are used every third, fourth, or fifth plot, the border rows should be discarded to avoid the effects of possible crossing and disease contamination. At all times during the growing season, one should be on the lookout for off-type plants. These should be rogued at once. Vining types of plants sometimes occur as sports or mutants in bush varieties. This may represent a tendency to revert to

the original type from which bush forms were derived. A familiar example of reversion to the vining type occurs in Red Kidneys. This is referred to in official bean grades as "blue beans" because these mutant plants bear seed of a bluish red color. They are similar in shape to medium beans.

### IMPROVEMENT BY BREEDING

As stated earlier in this chapter, bean breeding has two fundamental aims; first, to determine the facts of inheritance, and second to produce improved types or varieties which can be grown and marketed economically. Although comparatively few trained plant-breeders have worked with this crop, much of value has been accomplished in respect to both of these objectives. The mode of inheritance of such factors as disease-resistance, self-color, mottling, and plant stature has now been determined. Resistance to specific bean diseases has been in several instances combined with high yield and good market type by crossing two commercial varieties each possessing usually only one or the other of these qualities.

#### *Technique of hybridization*

The plants which are to be hybridized are preferably grown in six-inch pots, one plant to a pot. Thus the plants can be set upon a table or bench, giving the worker an elbow rest while emasculating and pollinating the flowers. In case an early and a late variety are to be crossed, it is advisable to make two or three successive plantings at one-week intervals. In this way one is assured of getting flowers upon both varieties at the same time. Each parent plant is given a number and when a cross is made these numbers and such other

information as desired are put on a small tag and this tag is fastened to the flower-stalk. The plants as well as the surrounding atmosphere should be relatively dry when the cross is made as the pollen does not adhere so closely to the stigma under these conditions.

The flowers must be emasculated before the banner petal begins to open. Self-fertilization probably occurs about the time the flower-bud begins to open. The larger the flower-bud, the easier it is to emasculate, and for this reason it is desirable to emasculate just previous to opening; although the stigma seems to be receptive several hours before the petals open. The bud is carefully opened with a pair of small forceps and the banner petal folded back. One or both of the wing petals are pinched off. The spiral keel is then slit with a teasing needle, and opened with the forceps leaving anthers and stigma exposed. The former are carefully pinched off with the forceps without injuring the pistil and also are carefully prevented from coming in contact with the stigma or the hairs on the style just below the stigma. After the ten anthers are removed a mature fully-opened flower is taken from the male parent plant. By binding back the wing petals, the stigma is forced out of the spiral keel. This stigma is then brought in contact with that of the female parent and the pollen is rubbed off upon it. The banner petal is then folded back over the pistil of the emasculated flower, furnishing some slight protection. Under favorable conditions the young carpel can be noticed in twenty-four to forty-eight hours after making a successful cross.

Bagging is necessary for both the male and female flowers unless the plants are grown in winter in the greenhouse or under other conditions where insects,

especially bumblebees, do not have access to the plants.

It is an exception even for an experienced bean breeder[1] to make a cross without having one or two and frequently more self-fertilized seed occurring in the pod with the hybrid seed. But generally these can be identified in the $F_1$ generation by their strict resemblance in all characters to the female parent. In cases in which one is doubtful concerning the identification of these plants in the first generation, seed from them is kept separate and planted. The absence of segregation then, of course, furnishes unquestionable proof.

### INHERITANCE OF CHARACTERS

One of the first characters studied with respect to mode of inheritance was stature of plant. Emerson[2] has shown that in some crosses of tall and short bean plants, the results are explainable on a single factor basis while in others several factor differences are involved. In a cross between a tall pole bean and a short bush form, he explains the results on a three-factor hypothesis since in the $F_2$ generation from the cross he obtained talls, various degrees of intermediates and short forms. By assigning specific internode number values to each of the three factors, A, B, and C, dependent on whether these factors were present in homozygous or heterozygous condition, the varying degrees of height occurring in the $F_2$ generation were accounted for. Shaw and Norton[3]

[1]Emerson, R. A. Neb. Agr. Exp. Sta. Rept., p. 32 (1902).

[2]Emerson, R. A. "A Genetic Study of Plant Height in *Phaseolus vulgaris*." Neb. Agr. Exp. Sta. Res. Bull. 7 (1916).

[3]Shaw, J. K., and Norton, John B. "The Inheritance of Seed Coat Color in Garden Beans." Mass. Agr. Exp. Sta. Bull. 185 (1918).

made a very comprehensive study of the inheritance of seed-coat color in garden beans, their work comprising over 120 different crosses with twenty-one varieties involving 40,000 plants. Their crosses included mottled, self-colored, and white varieties in various combinations. Quoting from a summary of their results, "In a general way the crosses of pigmented and white beans show a 3:1 ratio, but there are some rather wide departures which may or may not be of genetic significance. The inheritance of mottling may be explained by the double factor hypothesis of Emerson and Spillman. Crosses of two mottled varieties have in all cases given only mottled progeny. Crosses of mottled and self-colored varieties have yielded mottled beans in $F_1$, and the parent types in a 3:1 ratio in $F_2$. Crosses of mottled and white varieties have given mottled beans in $F_1$, and usually mottled, self-colored and white in a 9:3:4 proportion in $F_2$." These investigators demonstrated that pigment colors and pigment patterns are controlled by distinct genetic factors. Recently, K. Sax and H. C. McPhee at the Maine Experiment Station [1] have worked extensively with color inheritance in Yelloweye beans. In crosses between the Old Fashioned Yelloweye and Improved Yelloweye all gradations and patterns in eye pigmentation occurred in the $F_2$ generation. These authors also report evidence that the factor for seed weight is linked with factors for pigmentation, eye pattern, and extension. Emerson's most recently reported experiments on color inheritance involve crosses between self-colored and white varieties. These crosses gave mottled beans in the $F_1$ and mottled, self-colored, and white in the $F_2$ approximating the theoretical ratio of 9:3:4 respectively.

[1] Abstract in Maine Exp. Sta. Bull. 315 (1923).

He explains this performance by using the presence and absence formula of Shull in which P and p stand for the factor presence and absence of pigment; M and m for the presence and absence of mottling; Pm for self-colored; pM for white; and PM for mottled.

Hayes and Garber[1] report a summary by Tschermak, a German investigator, in which is indicated the mode of inheritance of several economic characters in garden beans. This summary is given in Table XXII.

TABLE XXII

INHERITANCE IN THE BEAN (after Tschermak)

| Contrasted Characters | $F_1$ Condition | $F_2$ Behavior |
|---|---|---|
| Colored x white (flowers) | Colored | 3 : 1 |
| Green x yellow (unripe pods) | Green | 3 : 1 |
| Non-constricted x constricted (pods) | Non-constricted | 3 : 1 |
| Round x flat (pods) | Round | 3 : 1 |
| "Non-stringiness" x "stringy" (pods) | Intermediate or approaching non-stringiness | Stringy pods recessive (1 out of 4) |
| Blunt x sharp (pod ends) | Approaches blunt | Approaches 3 : 1 |
| Broad x narrow (pods) | Approaches broad | Segregation irregular |
| Long x short (pods) | Approaches long | Segregation irregular |
| Cylindrical x spherical (seeds) | Approaches cylindrical | Segregation irregular with spherical seeds constant |
| Cylindrical x kidney shaped (seeds) | Approaches cylindrical | Segregation irregular with kidney-shaped seeds constant |
| Yellow x green (cotyledons) | Yellow (apparent on crossed seed) | 3 : 1 (segregation apparent on $F_1$ plants) |

## DISEASE-RESISTANCE

No single phase of bean production has caused the

[1] Hayes, Herbert Kendall and Garber, Ralph John. "Breeding Crop Plants." McGraw-Hill Book Company, Inc., p. 244 (1921).

grower more anxiety and loss than the more serious diseases. As indicated in the chapter on diseases, anthracnose and bacterial blight are seasonal troubles and no practical method of control, such as spraying and seed treatment, has been sufficiently effective to prevent large annual losses. The most promising means of control which has been so far devised is breeding for disease-resistance. Before this factor could be studied with respect to its mode of inheritance, it was necessary first to discover and select under field conditions specimen plants which exhibited resistant qualities and subsequently to test these for their true-breeding tendencies. Considerable progress has been made during the last decade with anthracnose resistance. Although much has been attempted with bacterial blight and dry root-rot, little has been accomplished.

Barrus[1] made the first notable comprehensive attempt to study the susceptibility of standard bean varieties to anthracnose. Using over two hundred varieties and cultures of the fungus obtained from scattered geographical areas, he was able to classify beans in four groups with respect to their susceptibility or resistance to the two common strains of *Colletotrichum lindemuthianum* as follows:

(ab) Varieties susceptible to both strain alpha and strain beta.

(aB) Varieties susceptible to strain alpha but resistant to strain beta.

(Ab) Varieties susceptible to strain beta but resistant to strain alpha.

[1]Barrus, Mortier F. "Bean Anthracnose." Cornell Univ. Agr. Exp. Sta. Memoir 42 (1921).

(AB) Varieties showing some resistance to both strains.

The most outstanding variety in the last group is the Wells Red Kidney which has been mentioned as a valuable parent stock used in crossing with other commercial sorts. Burkholder,[1] working at the Cornell Station, crossed this parent on to the common White Marrow which is resistant to only the alpha strain and obtained plants resistant to both beta and alpha strains in the $F_2$ generation in the ratio of 3:1. As a result of this cross, he produced the variety Perry Marrow which is notably resistant to both alpha and beta strains of anthracnose. McRostie,[2] working at the same station, has reported the mode of inheritance of resistance to anthracnose, to mosaic, and to dry root-rot in several crosses made at the Perry Bean Laboratory, Perry, New York. When only one strain of the fungus is concerned in the cross, resistance is inherited on a single factor basis. When both strains are concerned the two-factor hypothesis is involved, resistance being dominant. With crosses in which Michigan Robust Pea was used as the mosaic-resistant parent, resistance to mosaic was inherited on the two-factor basis, susceptibility being partially dominant over resistance. Results from similar studies with dry root-rot were not so clear cut but seemed to justify explanation on the two-factor hypothesis with susceptibility dominant over resistance. As a result of these and other studies, it appears likely that the ultimate solution

[1]Burkholder, W. H. "The Production of an Anthracnose-resistant White Marrow Bean." In Phytopath. 8: 353-359 (1918).

[2]McRostie, G. P. "Inheritance of Disease Resistance in the Common Bean." Jour. Amer. Soc. Agron. 13: 1, 15-32 (1921).

of bean disease control problems will come with the development of resistant varieties.

### CORRELATION OF CHARACTERS

Very few studies in the correlation of characters in beans are on record. Shaw and Norton[1] report the correlation of seed and flower color by which all white or eyed beans are accompanied by white flowers; all black or black mottled beans by dark pink flowers; mottled beans, other than black mottled and those of various yellow and brown colors, usually by light pink flowers. The author has observed through study of many varieties and strains of red beans a very general accompaniment of pink flowers.

One can scarcely dismiss the subject of bean breeding and improvement without mention of the valuable work of N. B. Keeney, of Le Roy, New York. By keen powers of observation, skill in the art of practical plant-breeding and years of painstaking effort, he, perhaps more than any other, has been responsible for improvement in garden varieties. His abilities in the amelioration of stringiness, pod type and canning quality have been long recognized by seedsmen throughout the country.

[1] Mass. Agr. Exp. Sta. Bull. 185, p. 102 (1918).

## CHAPTER XV

## *STRING-BEANS AS A TRUCK CROP*

The string-bean is recognized as one of the most delectable fresh vegetables used on the American table. Although the average city dweller is more familiar with it in canned form in which condition it may be equally tender, the peculiarly pleasing flavor of snap-beans fresh from the garden cannot be duplicated. The demand for the fresh product over a large part of the year, particularly during the winter season in the North, is the basis for the production of string-beans as a truck crop in many different sections.

### PRODUCTION AREAS

According to the 1920 United States Census, 57 per cent of the total acreage of green beans was raised in the states shown in Table XXIII.

TABLE XXIII

ACREAGE OF GREEN BEANS RAISED FOR SALE BY PRINCIPAL STATES AND U. S. (CENSUS OF 1920)

| State. | Acreage. |
|---|---|
| Florida | 8,522 |
| New York | 6,628 |
| New Jersey | 6,091 |
| Maryland | 5,187 |
| Tennessee | 4,322 |
| California | 4,126 |
| Kentucky | 3,358 |
| Virginia | 3,024 |
| United States | 71,970 |

About one-third of the total crop was produced in the South Atlantic states, indicating the relatively great importance of the crop in this region. In connection with the above list of states it should be noted that a considerable part of the acreage listed for New York and Maryland was probably canned. Twenty states produce over 1,000 acres annually, very few being grown in the arid and semi-arid mountain states. Added to the above is the large production in home-gardens where string-beans occur probably as commonly as any other single vegetable grown. They fit well into the farming scheme of the southern truck-grower because they can be planted in either spring or fall, they thrive well in the warm autumn temperatures, and they do not compete with northern-grown forced vegetables to the same extent as most southern truck crops.

## CULTURAL PRACTICES

The soil adaptations, methods of planting, and cultural practices are in most respects similar to those described for field or dry-shell beans. Somewhat stronger more fertile soils than those commonly used for field beans are preferred. In many trucking sections they are used as a companion crop with strawberries, and young fruit-trees. In the South, beans are sometimes planted after the early crop of cabbage, being well adapted for this on account of their short growing season requirement. Successive plantings every ten days to two weeks may be made to prolong the period of marketing.

Since earliness is usually important because of its relation to profitable marketing, soils well supplied with readily available nitrogen are recommended. This facil-

itates early vigorous growth as well as yield. Speth,[1] at the Georgia Experiment Station, studied the effects on yield of various kinds and amounts of fertilizer used on 100-plant plots of the variety Early Valentine. Nitrate of soda and cottonseed meal were compared as sources of nitrogen and no advantage was shown for either. Using superphosphate and muriate of potash as the sources of phosphoric acid and potash respectively, he found that doubling the ration of nitrogen and of potash gave no appreciable increase in yield.

A later and somewhat more comprehensive fertilizer test was made by Ferris [2] at the Mississippi Station. He applied a fertilizer ratio of 3-7-3 (the 7 representing nitrogen in this case) obtained from cottonseed meal, dried blood, acid phosphate, and kainit in amounts from 736 to 988 pounds to the acre to one-fourth acre plots planted with both Wardwell's Kidney Wax and Improved Valentine varieties. The yields were larger when no potash was used than when it was applied with varying amounts of nitrogen and phosphoric acid. Although no check plots were included in the experiment, the author concluded that on soils in the condition of those employed, more profitable crops can be grown with 500 pounds than with 1,000 pounds an acre applications.

As with field beans, bush varieties of string-beans are now planted mainly in drills rather than in hills, the plant spacing being about the same. On the average, about a bushel of seed to the acre is used. Pole varieties,

[1]Speth, G. "Experiments in the Culture of Vegetables." Ga. Agr. Exp. Sta. Bull. 14, pp. 81-82 (1891).

[2]Ferris, E. B. "Report of Work at the McNeill Branch Station for 1902." Miss. Agr. Exp. Sta. Bull. 79, pp. 16-18 (1903).

because of the necessity of using poles, are planted in hills spaced usually three to four feet apart in the row.

### FORCING BEANS

The production of string-beans in the greenhouse has never become an important and seldom a profitable enterprise, although in England the greenhouse forcing of beans is said to be an established practice. In America, tomatoes, cucumbers, and lettuce have proved more profitable than beans for greenhouse production. When grown in this way, however, beans are said to be more profitable as a spring than as a fall or winter crop. Being naturally a long-day type of plant, the bean does not blossom and set seed well in the winter season. Probably beans are most often grown after a winter crop of lettuce in the greenhouse.

According to Green,[1] the bush varieties best adapted for forcing are early maturing, prolific, and with long straight smooth pods. Most of these are of the green-podded type and are of English origin such, for example, as Masterpiece, Earliest of All, Plentiful, Sunrise, and Triumph of the Frames. In a three-year test by Green, he found that most of the varieties tested reached the first picking stage in sixty-two to seventy-nine days after seeding. Among the precautions to be observed in forcing beans are that the plants should not be over-watered and such pests as the green aphis and the red-spider be guarded against.

### VARIETIES

String-bean varieties of both wax and green-podded

[1]Green, S. N. "Bush Beans in the Greenhouse." Ohio Agr. Exp. Sta. Monthly Bull. III, No. 1, pp. 16-20 (1918).

types are discussed in the chapter on vareties. Among the most popular bush varieties grown in trucking regions are Refugee, Black Valentine, Bountiful, Wardwell's Kidney Wax, Red Valentine, Stringless Green Pod, Davis' White Wax, Currie's Rustproof Wax, Early Mohawk, Full Measure, and Dwarf Horticultural. Common varieties of pole beans include Kentucky Wonder Wax, Kentucky Wonder (green-pod), Golden Cluster, Lazy Wife, Creaseback, Mont d' Or, and Scotia.

Formerly, wax-podded were more popular than green-podded varieties as they were thought to be less stringy and of better appearance in the market. Since the development of improved strains of relatively stringless varieties of green-pods, the latter are now the more popular in many markets. Owing to this differential preference among markets, it is usually advisable to grow both green-podded and wax-podded types. It is common opinion that stringiness in snap-beans can be detected by the character of the lower point of the pod. If the latter is rigid, the product is more stringy than when the point is curved and limp.

Green-shell varieties, such as Dwarf Horticultural, are grown mostly for home consumption. The large amount of labor involved in shelling makes this type less popular than snap-beans in most markets.

### DISEASES

The diseases to which snap-beans are susceptible are in general the same as those which prey upon field beans. These are discussed rather fully in the chapter on diseases. Rapp,[1] at the Arkansas Experiment Station, says

[1]Rapp, C. W. "Some Important Factors in Snap Bean Production." Proceedings 17th Annual Meeting Amer. Soc. Hort. Sci., pp. 116-119 (1920).

that snap-bean diseases are much worse on the spring-grown than on the fall-grown crops. Anthracnose and blight, according to him, are especially difficult to control except by fall cropping and the use of a carefully controlled seed-plot. He suggests the use of seed at least two years old as a further means of control on the theory that seed-borne diseases lose their virulence in seed older than one year. However, this involves the fact that seed more than a year old is relatively less viable.

### HARVESTING

Quality in string-beans is greatly influenced by their stage of maturity at harvest. If too immature, yield is sacrificed and their nutritive value is no greater than in beans at the proper stage of maturity. If too mature, tenderness, palatibility, nutritive value, and edibility are sacrificed. The best edible stage for harvesting is indicated at a time when the seeds just begin to swell within the pod. This can be detected best by snapping a few pods.

Hand labor is employed in harvesting and usually two or three pickings are necessary in order to obtain the maximum crop of beans in best edible stage. Much negro labor is employed in the South for this purpose. Women and children, often of foreign extraction, are largely used in the North. Wages for picking are paid usually on the basis of weight or number of hampers or baskets.

### MARKETING

If the harvested beans are affected with disease, defective pods or weathering, it is necessary to resort or grade them before packing for market. The crop is shipped in various types of containers from the various producing

areas. Half-bushel, bushel, and half-barrel hampers, and boxes are used. The round stave bushel basket is now a popular package in some sections. String-beans are subject to considerable shrinkage during shipment, hence containers should be filled to take this into account. For long-distance shipments in warm weather, refrigerator cars are necessary.

# CHAPTER XVI

## *THE BEAN CANNING INDUSTRY*

STRING-BEANS, dry-shell beans, and limas in cooked form are available to the consumer in tin cans of various sizes. The technique necessary for the canning of string-beans was not developed until considerably later than that for the canning of peas and tomatoes. Nevertheless, the rapid increase in volume of beans packed in recent years is evidence of an increasing appreciation of this commodity. Both wax-podded and green-podded varieties of string-beans are canned either in the form of small whole pods or as large pods cut into half-inch pieces. When canned as small whole pods, the beans are sold as fancy grade and bring a comparatively high price.

### ECONOMIC CONSIDERATIONS

According to the Canners' Almanac for 1926,[1] the total pack of beans other than baked beans in 1923 in the United States was 6,044,051 cases of twenty-four No. 2 cans valued at $14,372,579. Compared to these figures, the pack of baked beans in 1923 was 14,424,043 cases valued at $25,265,479. Therefore, the total pack of all beans was approximately 20,000,000 cases valued at about $40,000,000 while the pack of tomatoes, peas,

[1] "Almanac of the Canning Industry, 1926." The Canning Trade, Baltimore, pp. 1-162 (1926).

and sweet corn was somewhat in excess of 14,000,000 cases each. The acreage, production, and pack of string-beans more than doubled in the four-year period of 1922 to 1925 inclusive. More than one-half of the total acreage, production, and pack of string-beans is in the five states, New York, Wisconsin, Maryland. Michigan, and Colorado, according to Table XXIV.

TABLE XXIV

SNAP-BEANS FOR CANNING (AVE. 1922-1925). (COMPILED FROM 1926 ALMANAC OF THE CANNING INDUSTRY)

| State | Acreage | Yield to the Acre (Tons) | Production (Tons) | Price a Ton Paid by Consumers | No. of Cases of 24 No. 2 Cans* |
|---|---|---|---|---|---|
| New York. | 5,102 | 2.2 | 11,275 | $81.07 | 721,711 |
| Wisconsin. | 2,857 | 2.0 | 5,350 | 65.51 | 380,728 |
| Maryland. | 1,815 | 1.8 | 2,850 | 56.29 | 965,208 |
| Michigan.. | 1,802 | 1.2 | 2,200 | 58.50 | 662,765 |
| Colorado.. | 1,052 | 3.0 | 3,175 | 58.33 | 171,426 |
| United States .. | 21,220 | 2.1 | 43,475 | $63.19 | 6,044,051 |

* Figures from 1923 census only.

The factors which determine the geography of production of beans for the cannery are rather distinct from those concerned with the other leading canning crops. Climate, soil, and cropping system are of minor importance. Economical production depends mainly on proximity to the canning factory, a plentiful supply of labor for harvesting the crop, and proper articulation with other canning crops grown in the same region or on the same farm. String-beans are grown for the cannery mainly in regions where other vegetables or fruits are

FIG. 31.—Snap beans ready for the cannery.

raised for the same purpose in order to provide fairly steady employment for canning factory labor and equipment over as long a period as possible. A common order of succession for the harvest of canning crops in many regions is peas, beans, sweet corn, tomatoes. However, there may be overlapping of these crops and all four are not necessarily handled at the same cannery. Beans for canning are grown either on land operated by the canning company or under contract with a land owner. In either case, large gangs of laborers are furnished by the canning company for hoeing and picking the beans. Wages for picking are paid either on the basis of quantity picked or at an hourly rate. In the latter case, a differential scale is used, whereby men, women, and children each receive a different wage.

Very few data on cost of production are available. Norton [1] has furnished cost of production figures for twenty-two acres of string-beans grown on three farms in Orleans County, New York, in 1920. The average cost of production an acre was $60.25 not including cost of picking which was furnished by the canner. Owing to a subnormal average yield of only 2,432 pounds an acre and a price of $40 a ton, the net returns on these farms were —$11.61 an acre.

### TYPES AND VARIETIES CANNED

The types of beans most commonly canned are both wax-podded and green-podded string-beans, limas, pea beans, red kidneys, and yelloweyes. The three last-named varieties of dry-shell beans are baked with pork

[1] Norton, L. J. "An Economic Study of the Production of Canning Crops in New York." Cornell Univ. Agr. Exp. Sta. Bull. 412, pp. 77-78 (1922).

or with tomato sauce before canning. Pea beans are used most while the canning of red kidneys is increasing. Yelloweyes are canned mainly in the vicinity of Boston and Providence for the New England markets. A demand for the strain of Red Kidney known as Mahogany Red has developed recently among certain canners. The dark red color in this strain is said to be popular because it affords a better appearance than the common Red Kidney in the canned product.

To be well adapted for canning, a string-bean variety should be relatively stringless, tender, of good flavor, and retain its color in the canning process. Varieties which meet these requirements well and are now extensively grown for canning are Refugee (Fig. 32) and Stringless Refugee Wax. Early Refugee, Refugee Green Pod, Golden Refugee, Hodson Wax and Round Yellow Wax are also much used. Clean attractive pods are essential for canning, hence the importance of choosing varieties resistant to the anthracnose or pod-spot disease. There is urgent need for the development of anthracnose-resistant varieties of string-beans for canning.

### CULTURAL FACTORS

The climatic and soil requirements for cannery beans are essentially the same as those for common beans. Fairly fertile soils well supplied with available nitrogen to provide an early vigorous start are desirable. Although cannery beans are usually rotated with other crops, they occupy no fixed place in the rotation. It is desirable to precede beans with clover or some other crop, leaving a weed-free sod residue when possible.

Fertilizer practice is similar to that for common field beans. In New York, seldom more than 200 to 300

pounds an acre of commercial fertilizer are used. The analyses vary, 4-12-4, 4-8-6, and 16 per cent acid phosphate being common.

The average seeding rate is about one bushel to the acre, the seed being drilled 1 to 3 inches apart in rows

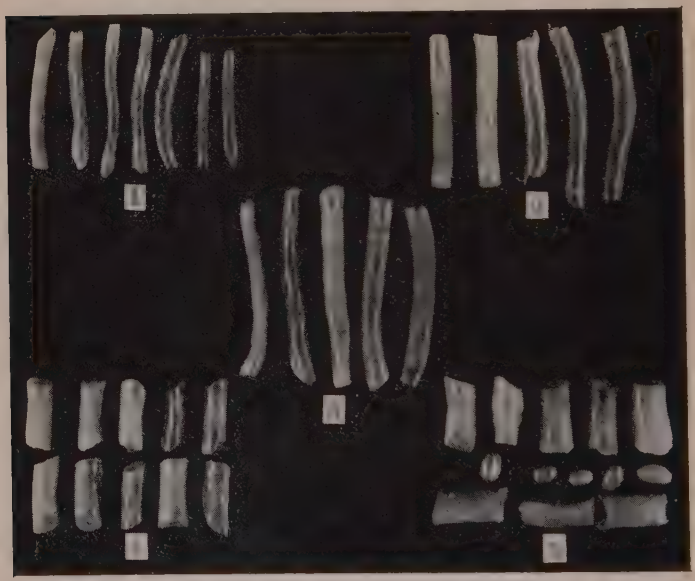

FIG. 32.—Market grades of string-beans for canning. Variety, Refugee: (1) Fancy Tiny Refugee, (2) Fancy Small Refugee, (3) Fancy Refugee, (4) Extra Standard Cut Refugee, (5) Standard Cut Refugee.

varying from 26 inches to 42 inches apart. Wider spacings lend the advantages of less disease dissemination and less trampling of the plants at picking time. While yields average about two tons to the acre, yields of three tons are not uncommon.

### RELATION BETWEEN GROWER AND CANNER

Much of the acreage of cannery beans is operated entirely by the canning company on land leased for a term of years. In other cases, the crop is grown subject to contract between grower and canner. The contract usually stipulates the acreage and the variety to be grown and the price to be paid either on the flat or graded basis. The canner furnishes the seed at a stated price and assumes entire charge of the picking. The grower usually agrees to haul the beans to the cannery. Two or three pickings, depending on the season, are usually necessary to insure the maximum yield of beans in the best canning condition.

When the crop is bought on the graded basis, the price paid the grower is inversely proportional to the size of the pods, the latter being determined by test at the canning factory. The scale of prices used in Chautauqua County, New York, in 1921 for beans grading 130, 200, and 340 pods to the pound was 2, 5, and 8 cents a pound, respectively.

### CANNING METHODS

In order to insure uniformity of quality, standard pack, and good appearance in canned string-beans, the delivered crop is graded into various sizes at the factory. Small, immature, tender pods are canned whole and sold as fancy or extra fancy grade. The larger pods are graded into sizes and packed as extra standard or standard cut beans. Formerly much hand labor was necessary to snip off the ends and remove the strings from the larger pods, but this work is now done mechanically. Large, perforated, metal, rotating cylinders have

been developed for the snipping process. Also the cutting of the pods is now done mechanically. Women are employed to remove defective pods as the latter pass over endless conveyors. Preparatory to processing, the delivered beans are washed, graded, snipped, blanched and placed in the cans.

String-beans are packed mainly in No. 2 cans each containing 1 pound 3 ounces. The fancy grade is sometimes packed in No. 1 cans containing 10½ ounces. For hotel and restaurant trade, No. 10 cans containing 6 pounds 6 ounces are used.

## CHAPTER XVII

## *DRY-LAND CULTIVATION OF BEANS*

In spite of the relatively high humidity and moderate temperature requirements of the common bean, *Phaseolus vulgaris*, the production of beans for local consumption is a fairly well developed industry in many sections of the semi-arid southwestern states. Beans are a common, almost daily, article of food among the Indian tribes and Spanish settlers throughout southern Arizona and northern Sonora, Mexico. Dry-land production also extends across New Mexico, into southern California and to some extent into Colorado. In many parts of this region where irrigation water is available, cultural practices are modified to make best use of this facility. In other parts, certain varieties adapted to withstand drought and extremes of heat are grown.

### VARIETIES

Such varieties as Pinto, Pink, and Red Mexican belonging to the *P. vulgaris* species, although probably more heat- and drought-resistant than the common varieties grown in the humid regions, are not as well adapted to semi-arid conditions as the Tepary, *P. acutifolius* var. *latifolius*. This variety has been extensively studied, classified, and described by Freeman.[1] It is said to

[1]Freeman, G. F. "Southwestern Beans and Teparies." Ariz. Agr. Exp. Sta. Bull. 68 (1912).

have had not only an origin distinct from the kidney bean, but to be botanically distinct in being more resistant to heat, drought, and insect attacks, hence more productive in semi-arid regions. According to Freeman, the seeds are smaller averaging about .15 grams, and lack the characteristic glossiness in sead-coat. The flowers and leaves are also smaller, the latter having distinctly shorter petioles and being narrower, smoother and with truncate instead of cordate base as in the kidney type. The seed is of various colors including white, pink, yellow, brown and black, some being self-colored, others flecked and mottled. The vines are usually trailing and bear many small four- to five-seeded straight pods. The variety is considerably lower in quality than more common sorts and is not popular on most markets.

### PLANTING AND IRRIGATION

Soil preparation and planting methods are largely dependent on the supply of available soil-moisture. In California, early beans are rarely irrigated, while plantings made after June 1st, except on naturally moist soils, are dependent on irrigation. Here it has been found that one three-acre inch application of water before, and two similar applications after planting have usually proved best. Broad shallow trenches are prepared between the rows and small streams of water run through them until the soil has become well moistened. If planted in dry soil which is not to be irrigated at once, the seed must be planted deeply enough to reach moist soil. This may mean planting as deep as five inches. Listing in shallow furrows is sometimes practiced in order to reach moisture without covering the seed too

deep, but is not recommended except when the plowed soil is subject to blowing. Contact of the pods with the soil as the crop approaches maturity is a serious objection to this practice.

Kezer[1] reports as a result of irrigation studies in eight counties of Colorado, that beans should be irrigated when the need for water is shown by a very dark green color and a tendency of the plants to wilt during hot periods. Two main methods of irrigation are practiced in Colorado and New Mexico. The thoroughly prepared seed-bed may be irrigated first, then planted as soon as it dries to a workable condition, or it may be planted and then "irrigated up." If the latter method is followed, the planting depth should not exceed three inches. Under the latter system there is danger that a crust may form and interfere with germination, and weeds may start so early as to compete with the beans. Late irrigations are not recommended because they tend to delay maturity.

Planting distances on dry land range from 3 to 7 feet between rows and from 6 to 12 inches between plants in the row, the wider spacings being recommended on the drier soils. Under irrigation the plant spacing is about the same as in humid regions. According to Kezer from 8 to 20 pounds of seed, probably an average of 15 pounds, to the acre are required for dry-land culture.

### HARVESTING

It is not advisable to wait until the pods have completely matured before harvesting on account of the

[1]Kezer, Alvin. "Beans in Colorado." Colo. Agr. Exp. Sta. Bull. 234 (1918).

danger of loss from shattering. The vines should be pulled when the pods are yellow, but not yet dry. Harvesting when the plants are moist with dew will avoid much shattering. Although much of the dry-land crop in New Mexico and Arizona is pulled by hand, bean-harvesters are rapidly being introduced. Similarly much of the threshing is still done by flailing or by using horses and mules to trample the seed from the pods.

Yields obtained in dry-land cultivation, particularly of the Tepary and Pink varieties, average 6 to 8 bushels to the acre. Yields produced under irrigation average much higher.

## CHAPTER XVIII

## *LIMA BEANS*

THERE is good evidence that the lima bean is native to South America, probably being first found in wild form in Brazil. It has been in cultivation among white peoples over three hundred years and today is considered one of the choicest vegetable delicacies on the American table. Lima beans are marketed as mature dry seed, as a canned shell-bean, and in the green pod as a fresh vegetable. In composition and in food value the lima is very similar to the common field or kidney bean of commerce. In these respects, however, it differs from the common bean, *Phaseolus vulgaris,* mainly in that more of its sugar-content is in the form of saccharose or cane-sugar, this accounting for its relatively sweeter taste.

### AREAS OF PRODUCTION

Although grown commercially for many years in Europe prior to production in the United States, the lima is now raised much more extensively in the latter country than elsewhere. For a long time, market-gardeners near the large cities of the East as well as many home-gardeners, have grown the pole lima as a green-shelled bean. Bergen County, and the area around Hackensack, New Jersey, first came to be known as the center of the lima bean-growing industry. A little later the lima became a market-garden and a truck crop in

Maryland, Pennsylvania, Virginia, Delaware and the Carolinas. Considerable acreage is now grown for canning in New Jersey, New York and Michigan.

However, the lima bean industry has reached its greatest development in southern California where in Ventura County alone the greater part of the crop of dry-shelled limas of the country is now grown. About 45 per cent of the California crop is of the lima, this production representing nearly 10 per cent of the total United States crop of dry beans. According to the United States Bureau of Agricultural Economics[1], the total crop of limas for the year 1925 was 1,870,000 bushels.

### CLIMATE AND SOIL REQUIREMENTS

The lima bean plant is very susceptible to frost-injury, even more so than the common field bean. Hence its culture is best developed in regions of fairly long growing season. Since most pole varieties are later maturing than the dwarf kinds, production of the former is limited to the warmer climates. With the introduction of early maturing dwarf varieties such as Henderson's Bush, Fordhook and Wonder Bush, it became possible to produce the crop further north than formerly. Nevertheless, the climatic factor limiting production in the northern states is early fall frost, in the middle western states low rainfall, and in California low humidity during the growing season and early autumn rains.

Lima beans thrive best in a warm sunny climate with relatively high humidity. Such a climate is available in the coastal regions of southern California where even with little or no rainfall during the growing season, high

[1]U. S. Dept Agr. Crops & Markets, Monthly Supplement, Vol. 3, Supp. 4, p. 111, April, 1926.

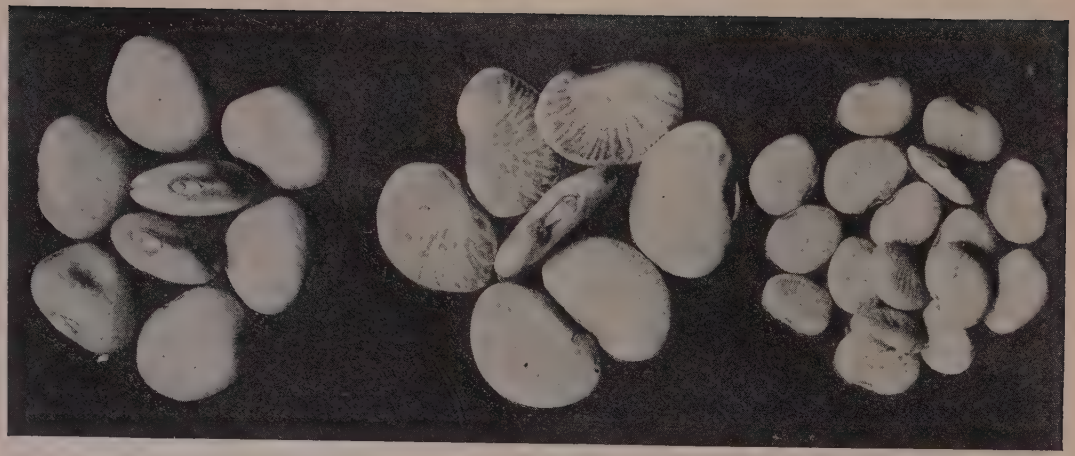

FIG. 33.—Three principal types of limas: left, Small Flat or Sieva; middle, Large Flat; right, Potato type.

humidity and fogs prevent excessive evaporation of moisture. Except for high rainfall, similar conditions prevail in the lima-bean-growing areas of New Jersey, Long Island, and other Atlantic coast regions.

Soil is a less limiting factor than climate although so-called "quick" or light soils conducive to early maturity are frequently essential. This is most true where the growing season is short and where the crop is to be matured. In canning crop sections, where early dwarf varieties are grown and it is not necessary to mature the seed, soil type is not so important. Because of the susceptibility of lima bean seed to rot when planted in cold wet soil, extremely heavy soils should not be used. Shaw and Sherwin [1] state that although the lima will withstand more alkali in the soil than varieties of the common or *P. vulgaris* species, the yield is frequently limited by this factor. Although the lime requirement of limas is apparently not high, the crop does best on neutral or slightly alkaline soils. The results with lime obtained in a three-year test at the New Jersey Experiment Station are shown in Table XXV.

A. W. Blair, in drawing conclusions from this experiment, states that evidently magnesian limestone had a greater corrective power than the calcium limestone and also that it had a depressive effect when applied in two-ton applications. The check plats receiving no lime were highly acid, while those receiving one ton an acre still had a considerable lime requirement indicating that "it is not necessary to fully satisfy the lime requirement to get good results." Soils with much nitrogen tend toward late maturity, hence this element should not be furnished in excess by the use of stable manure or highly

[1] Shaw, G. W., and Sherwin, M. E. "The Production of the Lima Bean." Calif. Agr. Exp. Sta. Bull. 224 (1911).

TABLE XXV

YIELD OF DRY-SHELLED LIMA BEANS IN 1921 COMPARED WITH 3-YEAR AVERAGE FROM LIME TREATMENTS (NEW JERSEY STATION)

| Treatment | 1921 | 3-Year Average |
|---|---|---|
| | Pounds to the Acre | Pounds to the Acre |
| No lime | 380 | 467 |
| ½ ton calcium limestone | 620 | 693 |
| ½ ton magnesian limestone | 1050 | 777 |
| 1 ton calcium limestone | 950 | 853 |
| 1 ton magnesian limestone | 1330 | 913 |
| 2 tons calcium limestone | 1370 | 935 |
| 2 tons magnesian limestone | 950 | 643 |

nitrogenous fertilizers. On the other hand, the mineral elements tend toward early maturity. It is generally conceded that limas require a richer soil than common beans and that pole varieties demand richer soils than do bush sorts.

### VARIETIES OF LIMA BEANS (Figs. 33-35)

Early cultivation of the lima consisted entirely of twining or pole varieties. These required the practice of planting in hills and the use of poles. This naturally increased the cost of production and tended to limit production to gardens and to small commercial plantings. The reader is referred to Chapter II for a brief description of the pole and dwarf types and of the three types of seed comprehended within each of these forms. Comparatively few varieties are listed by American seedsmen. The best classifications and descriptions are those of Jarvis[1] and Tracy[2]. These authors list about thirty

[1]Jarvis, C. D. "American Varieties of Beans." Cornell Univ. Agr. Exp. Sta. Bull. 260 (1908).

[2]Tracy, W. W., Jr. "American Varieties of Garden Beans." U. S. Dept. Agr. Bur. Pl. Ind. Bull. 109 (1907).

FIG. 34.—Pod types of lima
(Upper) Small Flat or Sieva, (middle) Large Flat, (lower) Potato type.

varieties and Tracy states that the total number of distinct varieties in the world is probably less than fifty. Most of these are the result of careful selection for improved types and the isolation of "sports" or mutations which have occurred in the original varieties. Hybridization has thus far failed to produce varieties of merit.

The original dwarf varieties were discovered as sports or mutations from existing pole varieties. Quoting Bailey,[1] "The Kumerle or Thorburn Dwarf Lima originated from occasional dwarf forms of the Challenger Pole Lima which J. W. Kumerle of Newark, New Jersey, found growing in his field. The Henderson, as we have seen, was a chance dwarf picked up in Virginia. The Burpee came from a single plant of the Large White Lima." Similarly, the variety Burpee Improved came from Burpee and variety Fordhook from Dreer. Since the original dwarf varieties were first introduced about 1889, nearly all present day varieties of this type have been developed within the last forty years. Bush beans are gaining rapidly in popularity especially in the East among the canners and the market-gardeners.

Almost the entire acreage in California is planted to pole varieties, but owing to the absence of rain during the growing season, poles are not used and the vines are allowed to run over the ground. Here the two most important varieties grown are Lewis and Daily. At least two-thirds of the entire acreage is planted to Lewis. The latter is somewhat vining, earlier and more prolific than Daily. Both of these varieties were developed locally by growers who selected for improved type and earliness. Other less important pole varieties grown in

[1]Bailey, L. H. "The Dwarf Lima Bean." Cornell Univ. Agr. Exp. Sta. Bull. 87 (1895).

California are King of the Garden and Carpinteria. Pole sorts are most common in the southern states while such bush varieties as Henderson, Fordhook and Burpee's Improved are grown in the corn-belt. Fordhook, a bush variety of the potato type, is the most popular one now grown by market-gardeners. This and Henderson's Bush are undoubtedly the leading varieties grown for canning in the East.

A brief description of some of the better known varieties follows:

*Dwarf varieties.*

Small Flat (Sieva or Carolina type)

*Henderson.* Small, erect, bushy plant with dark green glossy leaves. Very early, hardy, very productive. Pods and seeds very small and flat. Extensively grown. Hardy and disease-resistant. Quality only fair.

*Jackson Wonder.* Similar to Henderson, but somewhat larger and more spreading. Pods and seed slightly larger. Hardy and productive. Quality only fair. Color of seed pansy-violet, not popular. Not grown in North.

*Wood Prolific.* Similar to Henderson, but plant, pods and seed larger. An improvement over Henderson from which it is a selection. About one week later.

Potato type (Pods short, blunt, straight; seed turgid)

*Dreer.* Original bush variety of this type. Plant low and spreading. Hardy, very productive, late. Pods short, blunt, straight, turgid. Seeds medium large, turgid, excellent quality. Susceptible to disease and weathering because of low spreading habit.

*Fordhook.* A sport from Dreer. An improvement over Dreer. Plant more erect, hardier and much earlier than Dreer. Pods and seeds larger and more attractive. Very productive and excellent quality.

Large Flat type

*Burpee.* Original bush variety of this type. Plant large, spreading, some tendency to run. Large dark green leaves. Vigorous, hardy, very productive. Pods large, flat, broad, curved. Seed very large, flat, excellent quality. Very extensively grown but being supplanted by Burpee Improved and New Wonder or Wonder Bush.

*Burpee Improved.* An improvement by selection over Burpee. More erect and less tendency to run than Burpee. Pods very long, nearly straight and rather plump. Seed very large, plump, excellent quality. Season about same as Burpee and gradually replacing the latter.

*New Wonder.* A selection from Burpee and similar to it. Plant more erect, with less tendency to run. Pods straighter and wider with seed larger and flatter. Otherwise about the same as Burpee.

*Pole varieties.*

Small Flat (Sieva or Carolina type)

*Carolina.* Original variety of this type. Plant large, vigorous, early productive, a good climber. Pods and seed similar to Henderson though slightly larger. Quality not as good as in larger types.

Potato type (Pods short, blunt, straight; seeds turgid)

*Challenger.* Most popular variety of this type. A strain improved by selection from Dreer Pole. Plant large, vigorous, hardy, late, very productive and a good climber. Pods and beans medium large and turgid. Excellent quality.

*Dreer Pole.* Original variety of this type. Now largely superseded by Dreer Improved.

*Dreer Improved.* A strain selected for increased size of seed and earliness. Plant vigorous, very hardy, medium season, very productive. Pods straight, thick, containing 3 to 5 seeds set close together. Seeds light green and of excellent quality.

Large Flat type

*Carpinteria.* Developed in California. Of recent introduction. The result of selection for darker green tint in the seed. Popular among canners on this account. Plant vigorous, very productive. Seed broader and thicker than in most varieties of this type. Excellent quality.

*Daily.* Of recent origin. Vigorous grower, heavy twining habit, runners tending to set pods heavily. Midseason to late. Later and probably not so prolific as Lewis.

*Early Leviathan.* A good climber and moderately productive. The earliest variety of this type. Pods 5 to 6 inches long containing 5 to 6 large flat seeds. Good quality.

*Ford Mammoth.* Plant, pods and seed very large. Very similar to Large White. Attractive and good quality.

*Giant Podded.* Very vigorous and productive. Pods 7 to 8 inches long and very wide. Large thick seeds of excellent quality.

*Ideal.* One of the best general-purpose large-seeded varieties. Plant large, vigorous, good climber. Similar to King of the Garden, but earlier and more productive.

*Jersey.* Well known variety, but not very popular. Plant large, good climber. Season about a week earlier than Large White with pods and seed somewhat smaller.

*King of the Garden.* An improved strain of Large White. Very popular. Pods longer, wider and more curved than in Large White. Pods generally 4-seeded. Slightly later and more productive than Large White.

*Large White.* Original variety of this type. The standard pole lima, still very popular. Medium season and fairly productive. Pods 4 to 5 inches long, very flat, 3-to-4 seeded, good quality.

*Lewis.* Less vining in habit of growth and somewhat earlier than Daily. Very prolific. Well adapted to soils inclined to be wet. Smaller seeded than Daily.

*Salem.* A selection from Large White. Very vigorous grower, good climber. Season late. Pods very wide, flat, much curved. Excellent quality.

*Siebert.* Very similar to Jersey. Earlier and more productive than either Large White or Jersey. Pods very large and beans rather thicker and of excellent quality.

The following varieties are well recommended for the purposes indicated. Dwarf varieties for home use and market as green-shelled beans: Fordhook, Burpee Improved, New Wonder. Pole varieties for home use and market as green-shelled beans: (Early) Early Leviathan; (midseason) Ideal, Dreer Improved, King of the Garden or Giant Podded; (late) Challenger. Dwarf varieties for dry-shell production in the East: Henderson, Fordhook, New Wonder. Pole varieties for dry-shell production in California: Lewis, Daily.

### CULTIVATION OF LIMA BEANS

Lima beans are usually not grown in any fixed crop

FIG. 35.—Lima bean leaf types: Left, Small Flat or Sieva; middle, Large Flat; right, Potato type.

rotation. In the East this is due partly to the fact that the acreage is too small to allow of a convenient rotation with other more extensively grown crops. In most cases, the limas are grown either continuously or after another cultivated crop such as potatoes. In California large acreages are raised continuously on the same land with increasing yields an acre from year to year. It is considered good cultural practice to plow early and thoroughly prepare the seed-bed before planting. This largely avoids the necessity of intensive cultivation during the growing season and the danger of mechanical injury to the root system.

Most of the seed supply is now produced under favorable climatic conditions in California. Originally the eastern seed supply was grown mostly in Delaware. Because of the long growing season required by most varieties, the crop must be planted as early as the temperature and the soil are sufficiently warm to facilitate germination and to avoid rotting of the seed. Cracked seed germinates poorly or not at all and should be either removed or the amount of seed increased accordingly.

Date of planting depends on latitude and season. In California most of the planting is done from May 1st to 25th. The crop is planted around May 1st in New Jersey and on Long Island, while in New York and in the corn-belt the date corresponds with corn planting, namely May 25th to June 1st.

From 45 to 75 pounds of seed to the acre are planted, depending on such factors as soil-moisture and soil fertility, the higher rates being used when both are plentiful. Hand planting is still common on the smaller acreages while specially adjusted corn- or bean-planters are employed on the large acreages in California, New Jer-

sey and on Long Island. Pole varieties. where poles are used, are of necessity planted in hills with 2 to 4 seeds to a hill while the California crop, most of the cannery crop and the dwarf varieties are now planted in rows 30 to 36 inches apart with the seed distributed 6 to 12 inches apart in the row. Dimon [1] in 1921 conducted a test to determine the most favorable distances at which to plant bush limas. Using the Fordhook variety, he planted duplicate rows 20 feet long spacing the plants 24, 12, 6 and 3 inches apart in rows 24, 30, 33, and 36 inches apart respectively. In summarizing his results, he concluded that:

1. The thickness of planting had little, if any, effect upon the time of maturity of the plants.
2. The largest production of pods of good quality, as well as the largest total production, was made where the rows were two feet six inches apart and the plants six inches apart in the row.
3. The distance between rows has a greater effect on the quality of the crop than does the distance between plants.
4. The distance between plants has a greater effect on the production and growth of the plant than does the distance between rows.

Lima bean seed is said to have a weak germination, hence planting several seed in a hill tends to aid the young plant in breaking ground. Planting no deeper than one to two inches depending on soil type is recommended.

As previously stated, the soil-fertility requirements

[1] Dimon, C. E. "A Study of the Lima Bean." Cornell Univ. unpublished thesis (1914).

for the lima are somewhat higher than for the common bean. In the East, commercial fertilizer is very generally applied in the form of high grade complete mixtures in amounts varying from 800 to 2,000 pounds to the acre. An excess of nitrogen should be avoided as this causes a tendency of the plant to produce vine at the expense of seed. In the cannery sections of New York a 4-12-4 mixture is recommended. On Long Island and in New Jersey a 4-8-7 is commonly employed. Either stable manure or green-manure crops such as rye and vetch are used to maintain the humus-content of the lighter soils. It is important that whatever organic matter is supplied should be turned under in the fall or early spring to hasten its decomposition.

Farther west and in California little or no fertilizer is considered to be essential. No standard method of application is used, but growers are agreed that it must not be applied next to the seed on account of the danger of burning the tender seedling. Plenty of lime and humus should be available not only to satisfy the needs of the plant, but to furnish the most favorable conditions for the development of the nitrogen-fixing bacteria which associate themselves symbiotically with the plant. On account of the almost total absence of rainfall during the growing season in the lima bean region of southern California, early spring plowing, thorough seed-bed preparation, and a compacted subsoil with a surface soil mulch are provided to store up and conserve as much moisture as possible. It has been found profitable by these growers to furrow between the rows and irrigate once about the first of July. Two to three acre-inches of water are applied at this time. The water so sup-

plied is then conserved by again leveling the soil between the rows.

Two or three cultivations while the plants are young are all that are necessary in California where after a few weeks the vining plants cover the ground surface. In the East cultivations are more frequent, but late cultivation is to be avoided.

### DISEASES AND INSECTS

Among the diseases to which the lima has been reported subject are anthracnose, dry root-rot, rust, downy-mildew, Diaporthe pod-blight, bacterial spot, yeast spot, and bacterial streak. In California, owing to the dry climate, none of these is reported as at all common. In the more humid sections of the South and East, several occur infrequently, but seldom in serious form. Perhaps the most serious is downy-mildew caused by the fungus *Phytophthora phaseoli*, Thaxt. The disease is worst along the Atlantic coast in wet seasons of cool nights and hot days. The principal symptom is a downy white mold covering the pod. The disease may destroy 50 to 90 per cent of the crop in certain seasons. The fungus attacks all above-ground parts of the plant. Both dwarf and pole varieties are susceptible. Control is mainly by planting uninfected seed, destroying old bean vines, long rotations and wide spacing of the plants. Bordeaux spraying will help in the control, but it is not considered practicable. For detailed reference to this and the other diseases mentioned the reader is referred to Chupp's "Manual of Vegetable-Garden Diseases." [1]

[1] Chupp, Charles. "Manual of Vegetable-Garden Diseases." The Macmillan Company, pp. 647 (1925).

Very few kinds of insects attack this crop sufficiently to do serious damage. Of these, only three need be mentioned here, the lima bean pod-borer, *Etella zuickenella,* Freit; the common cut-worm; and the bean weevil, *Bruchus obtectus,* Say. The lima bean pod-borer is of some consequence in southern California, but little known in the East and South. The adult moth is scarcely more than one-half inch long, gray, and with ocherous blotches on the fore wings. The young larvæ, about one inch long, are white or light green becoming white or distinctly reddish above and greenish beneath when full grown. The insect most often attacks the bush varieties, the larva eating through the young pods and so into the seed. The adult moths appear about May. There is only one brood a year. The only control is to avoid planting bush varieties in regions where the insect is prevalent.

The common cutworm gnaws through the stems of the young seedlings, usually completely girdling them at the surface of the ground. This damage is usually done at night. The injury is frequently very serious unless a trap crop or poison bait is used for control. A convenient poison bait is a mixture of molasses, bran, and paris green rolled into balls and spread over the ground.

The bean weevil is seldom serious except occasionally in dry limas stored for seed. The description and control of this insect is given in Chapter X.

### HARVESTING

Except in California, nearly all lima beans are harvested in the green-shell condition when the pods have become fairly plump, but before they begin to turn yellow. The period of early harvest in New Jersey,

New York and other adjacent states begins in August and lasts until the first frost. Harvesting starts correspondingly earlier in the southern states. Grown for dry-shell purposes in California, the crop matures from August 20th to September 10th. There it is important to harvest early to avoid damage to the curing crop from early autumn rains. Bean-harvesters or "cutters" are generally used in California. These implements cut two rows at a time, pushing them together into one large row. For the cannery, the vines are cut with mowing machines, at once piled into small piles and within a few hours hauled direct to the vining station or cannery. If for dry-shell beans, these small piles are left to dry in the field usually from three to four weeks, depending on the weather.

A fair yield of dry-shell limas is 1,500 pounds to the acre, the yield usually varying from 1,200 to 2,500 pounds. Green-shell limas are picked by hand, most of the labor being paid for on the bushel basis. A good picker will harvest 20 bushels in a day. It is usually necessary to make two to four pickings of a field to insure harvesting the crop in best quality condition. Forty pounds of green-shell beans are accepted as a bushel while dry-shell limas weigh 60 pounds to the bushel. Specially constructed threshing machines are used in California. These are similar to grain-threshers, but have three cylinders revolving at a speed of 280 to 350 revolutions a minute instead of two revolving very much faster as in grain-threshers. Dry limas split easily and great care must be used to avoid this.

### MARKETING

Lima beans for the cannery are commonly grown on

contract, the seed being furnished by the canner, its cost being deducted from the grower's receipts. In this case the green crop is hauled like hay direct to the vining station. In most of the states producing green-shell

Fig. 36.—A hamper of limas ready for market.

limas, the bushel hamper is used as a market package (Fig. 36). In case of long distance shipment, icing of the cars is essential. Although this package adds to the cost of marketing as well as to the cost of the product, it is a means of adding attractiveness. Long Island

growers for many years have used narrow bags holding 38 pounds. These are cheaper, but less attractive. Most green-shell limas are retailed in bulk or in quart baskets. Dry limas grown in California are marketed in burlap bags holding 80 pounds. The small-seeded varieties such as Carolina Sieva and Henderson are commonly quoted in the market as baby limas in contradistinction to the larger varieties which are termed simply limas or regular limas.

The Bureau of Agricultural Economics of the United States Department of Agriculture has recently suggested the following standard of grades for lima beans for adoption and use by the various state and commercial agencies: Class XVIII. Lima Beans—This class shall include all large lima beans characteristic of the Large White Pole and Burpee Bush Lima varieties. Class XIX. Baby Lima Beans—This class shall include all small lima beans of the Henderson Bush and similar varieties commonly referred to as Baby Lima.

U. S. GRADES FOR LIMA BEANS

| U. S. Grade | Class and General Appearance | Maximum Limits of | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Blistered and Wrinkled Beans | Skinned and Broken Beans | Damaged Beans and Foreign Material | | | | | |
| | | | | Splits | Total | Worm Damage | Other Damage | Foreign Material | |
| | | | | | | | | Total | Rock |
| | Lima and Baby Lima | % | % | % | % | % | % | % | % |
| No. 1.. | Well screened* and of good color and appearance..... | 2.5 | 2.5 | 2.0 | 1.0 | 0.5 | 0.5 | 0.3 | 0.1 |
| No. 2.. | Well screened* and may be slightly off color..... | 5.0 | 5.0 | 3.0 | 2.0 | 1.0 | 1.0 | 0.5† | 0.2 |
| Sample Grade | Beans of the foregoing classes which do not meet the requirements for any of the numerical grades or which contain over 17% moisture, or have any commercially objectionable odor, or are heating, or weevily, or otherwise of distinctly low quality. | | | | | | | | |

* No. 1 Lima Beans shall be of a size such that not more than 40% will pass through a 32/64" round hole screen; No. 2 Lima Beans shall be of a size such that not more than 10% will pass through a 24/64" round hole screen and not more than 45% through a 28/64" round hole screen.

† No. 2 Baby Limas may contain not more than 1% of foreign material provided the total of damaged beans and foreign material does not exceed 2%.

## CHAPTER XIX

### *COWPEAS AND SOYBEANS*

For many years, the best lands of the southern states were continuously cropped to corn and cotton. There came a time when it became apparent that some provision must be made for the maintenance of soil organic matter in a cheap and efficient manner if cotton yields were to remain profitable. Such provision could not be made through the use of stable manure or commercial fertilizers alone. Furthermore, it was known that many of the less fertile soils could not be brought into condition for profitable cotton production without the use of economical soil-improving crops.

Cowpeas and soybeans were found, by trial, to be adapted in many ways to the maintenance of a profitable corn and cotton cash-crop type of agriculture such as was already well established in this region. These two rank-growing large-seeded legumes have much in common and logically may be discussed in a single chapter. Climatically they are similar, the range of production of the soybean being somewhat greater than that of the cowpea at the present time. Both are very sensitive to frost. Although their chief value lies in the use for soil-improving purposes, some utilization is made of the mature seed for both human consumption and for stock feed. Similarly, large acreages are grown as annual legumes cut green or cured for hay. They lend them-

selves well to production as companion crops with various intertilled crops at the same time beneficially influencing the cash crop with which they are grown. Although soybeans may be raised somewhat further north than cowpeas, the latter have proved more valuable for soil improvement because of their capacity to thrive well on very poor infertile soils.

### COWPEA *(Vigna sinensis)*

The cowpea is without question the most important legume grown in the southern states. There it occupies much the same position as a food crop as the common bean in the northern states.

The cowpea is apparently native to central Africa where wild forms are now commonly found. Morse[1] states that cowpeas are of three main groups; namely, cowpea (*V. sinensis*), catjang (*V. sinensis* var. *cylindrica*), and asparagus bean (*V. sinensis* var. *sesquipedalis*). The cowpea is probably the bean referred to by old Roman writers as Phaseolus. Seed of the three principal groups of cowpeas are illustrated in Figs. 37, 38 and 39. Of these three the common cowpea (*V. sinensis*) is most important in North America. Although called a pea, the cowpea is, correctly speaking, a bean. Aside from its use as a food crop in the South, it is employed also as a soil-improving and as a leguminous hay crop. Rotated between cotton and corn, it has proved to be of great value in maintaining the soil organic content for the benefit of these important southern cash crops. In this sense, the cowpea is to the cotton-belt what clover is to the dairy, corn and potato regions farther north.

[1]Morse, W. J. "Cowpeas: Culture and Varieties." U. S. Dept. Agr. Farmers Bull. 1148 (1920).

*Climatic and soil adaptations*

The cowpea is distinctly a warm-weather crop and, compared to the soybean, its principal areas of production do not extend as far northward, practically none being produced north of central Illinois, Indiana, Ohio, Pennsylvania, and New Jersey. It is even more susceptible to frost than the soybean. Although slightly

FIG. 37.—The common cowpea, *V. sinensis* variety Whippoorwill.

more drought-resistant than the latter, commercial production is limited to the more humid area of southeastern United States. The cowpea owes much of its great value as a soil-improving legume to the fact that it is well adapted to growth on a wide range of relatively acid and infertile soils. The two primary soil requisites for successful cultivation are, apparently, good drainage and soil inoculation.

*Varieties*

Choice of a variety should depend on such factors as adaptation to a given region and the use to be made of it. For forage the variety should be vigorous and high-yielding, erect in habit of growth, prolific in seed production with pods held well above the ground, and should ripen evenly and retain the leaves late in the season.

According to Morse[1], there are at present about fifteen

FIG. 38.—The asparagus bean, *V. sinensis* variety *sesquipedalis*.

varieties of cowpeas in common cultivation, while many others of lesser importance are occasionally grown. The varieties are distinguished most readily by color and size of the seed, although differing also in habit of growth and in season of maturity. Quoting from Morse: "The most valuable American varieties of cowpeas for forage

[1]Loc. cit., p. 7.

are the Whippoorwill, Iron, New Era, and their hybrids, the Brabham and Groit. Important, but of secondary value, are such indefinite groups of varieties as the Unknown, Clay, Red Ripper and Black. A large number of other varieties are grown to a small extent. For table use, the white-seeded varieties, such as the Conch

FIG. 39.—Catjang cowpea, *V. sinensis* variety *cylindrica.*

and Cream, and the Blackeye sorts, California Blackeye and Extra Early Blackeye are preferable."

*Planting*

When the crop is grown for seed or hay, it should be sown about corn-planting time. If raised for soil-improvement, green hay or pasturage, it may be seeded later. Seeding is most commonly done with the grain-drill, adjusting the drill-hose according to the distance between rows desired. For seed production, planting

in rows 3 feet apart with seed 2 to 3 inches apart in the row seems best. For forage or hay, drilling in rows 6 to 8 inches apart is recommended. In the former case, about 30 to 40 pounds of seed and in the latter case about 90 pounds of seed to the acre are required.

*Fertiizer*

The use of much fertilizer, particularly nitrogenous, has not been profitable. In very infertile soils, 50 to 75 pounds of nitrate of soda may be advisable. As in the case of soybeans, about 300 pounds of acid phosphate and 50 pounds of potash to the acre are commonly recommended.

*Harvesting and uses*

Cowpeas should be cut for hay or for ensilage when most of the pods are well developed and some of the leaves have begun to turn yellow. It is at this stage that maximum green weight of hay and high digestibility are obtained. When grown for seed, the crop should be cut when the maximum of pods are brown and the seed ripe. Formerly, these seed-pods were picked by hand with cheap labor in the South. Now, mowing machines and cowpea harvesters with special attachments for lifting the vines from the ground are employed. Both the hand flail and special pea-hullers are used to thresh the crop. Yields of one to two tons of hay and ten to fifteen bushels of seed to the acre are most common.

### SOYBEAN (*Glycine* or *Soja Max*)

According to Piper and Morse[1], the soybean is native

[1]Piper, Charles V., and Morse, William J. "The Soybean," pp. 329, figs. 84. McGraw-Hill Book Company, Inc. First Ed. 1923.

to eastern Asia where it was first known and is now an important crop in China, Manchuria and Korea. For years it has supplied oriental peoples with many complex forms of nitrogenous food. Recently its food value has begun to be appreciated in the United States, partly owing to its content of two of the more valuable vitamines. Its principal use in this country is for forage, pasture and ensilage purposes, only about 20 per cent being harvested for seed. It is estimated that approximately 950,000 acres of soybeans were grown in the United States in 1920. Piper and Morse predict a rapid development of the soybean industry in this country because of (1) its high yield and cheap production of seed, (2) its value as food, (3) the increasing importance of soybean oil and soybean cake, (4) its likelihood of replacing oats in the rotations of the corn-belt, and (5) its beneficial effects on other crops in the rotation.

*Climatic and soil adaptation*

Climatically the crop has about the same adaptation as corn and cotton. In the tropics, yields are poor due to failure of the pods to fill and in cool summers the plant does not thrive. Hence, commercial production is limited mainly to southeastern United States within the area bounded by the Ohio and Mississippi rivers. Its soil preferences are similar to those of corn, a more fertile soil being necessary than that required for cowpeas. Soil inoculation seems to be essential for soils which have not previously grown soybeans.

*Varieties* (Fig. 40)

Soybean varieties are very numerous both in Old

World countries and in America. The United States Department of Agriculture has tested upwards of 800 varieties to date. These exhibit a wide range in season of maturity, habit of growth and type of seed. Varieties differ in seed color from light yellow, through greens and variegated to black. All varieties, however, are annual and strictly determinate in habit of growth. While varieties vary from distinctly pubescent to smooth, most of the varieties in this country are pubescent. Piper and Morse[1] give the following key for the identification of varieties:

I. Yellow Group
  Seeds Straw Yellow
    Hilum pale
      Seed 4-5 mm. thick.....A. K.
      Seed 5-6 mm. thick
        Seed 7-8 mm. long.....Ito San
        Seed 8-9 mm. long.....Aksarben
        Seed 9-10 mm. long.....Elton
      Seed 6-7 mm. thick.....Mandarin
    Hilum tawny
      Seed 6-7 mm. long.....Hollybrook
      Seed 7-8 mm. long
        Hilum less than 1 mm. wide.....Pinpu
        Hilum more than 1 mm. wide.....Mammoth
    Hilum cinnamon brown
      Seed 4-5 mm. thick
        Seed 6-7 mm. long.....Minnsoy
        Seed 7-8 mm. long.....Chiquita
      Seed 5-6 mm. thick.....Hoosier
      Seed 6-7 mm. thick
        Seed 6-7 mm. long.....Mikado
        Seed 7-8 mm. long
          Hilum 3 mm. long.....Yokotenn
          Hilum 4 mm. long.....Easycook
    Hilum tawny to cinnamon brown.....Midwest
    Hilum dark olive.....Wea

[1]Loc. cit., pp. 171-172.

Hilum dusky brown
Seed 5-6 mm. thick.....Habaro
Seed 6-7 mm. thick.....Haberlandt
Hilum black.....Manchu
Seeds Olive Yellow
Hilum pale.....Tokio
Hilum tawny
Seed 6-7 mm. long.....Lexington
Seed 7-8 mm. long.....Morse
Hilum black.....Hahto

II. Green Group
Seeds Chromium Green
Seed 6-7 mm. long.....Columbia
Seed 7-8 mm. long.....Guelph

III. Brown Group
Seeds Olive
Seed 6-7 mm. long.....Barchet
Seed 8-9 mm. long
Seed 4-5 mm. thick.....Virginia
Seed 5-6 mm. thick.....Merko
Seeds Russet
Seed 6-7 mm. thick.....Chestnut
Seed 7-8 mm. thick.....Mammoth Brown
Seeds Auburn
Seed 7-8 mm. long.....Early Brown
Seed 8-9 mm. long.....Hamilton
Seeds Chocolate
Seed 8-9 mm. long.....Ogemaw
Seed 10-11 mm. long.....Biloxi

IV. Black Group
Seed 2-3 mm. thick.....Laredo
Seed 3-4 mm. thick
Seed 4-5 mm. wide.....Peking
Seed 5-6 mm. wide.....Wilson-Five
Seed 4-5 mm. thick
Seed 6-7 mm. long.....Ebony
Seed 8-9 mm. long.....Wisconsin Black
Seed 5-6 mm. thick
Seed 6-7 mm. long.....Otootan
Seed 8-9 mm. long.....Tarheel Black

V. Bicolored Group
Seeds Black and Brown
Black with brown saddle.....Black Eyebrow
Black and brown in concentric bands.....Meyer
Seeds Black and Olive Yellow
Black with olive yellow saddle.....Taha

Among the most important varieties in North America are Ito San, Mammoth, Guelph, Wilson, Black Eyebrow, Hollybrook, Haberlandt, Biloxi and Midwest.

*Planting*

Soybeans should ordinarily be sown at about corn-planting time or as soon as danger from severe frosts is over. Early planting is important in the cooler areas of the soybean belt in order to insure sufficient growing season for the yield of seed. Seeding in rows 24 to 36 inches apart to allow cultivation has given best yields under most conditions as the crop may otherwise be crowded by weeds. Seeded in this way, from 20 to 30 pounds of seed to the acre are used. When seeded broadcast for hay, from 1 to 1½ bushels of seed are required. Depth of seeding should not ordinarily exceed 2 inches.

*Rotation and fertilizers*

The crop is well adapted to a wide range of uses in the rotation, although it seldom occupies a regular place. In the South, it is often used between either grain or cultivated crops for soil improvement. Using early varieties in this region, two crops may be grown the same season. On account of the high protein content, soybeans are sometimes grown as a mixture with corn to improve the balance of the ration in the resulting ensi-

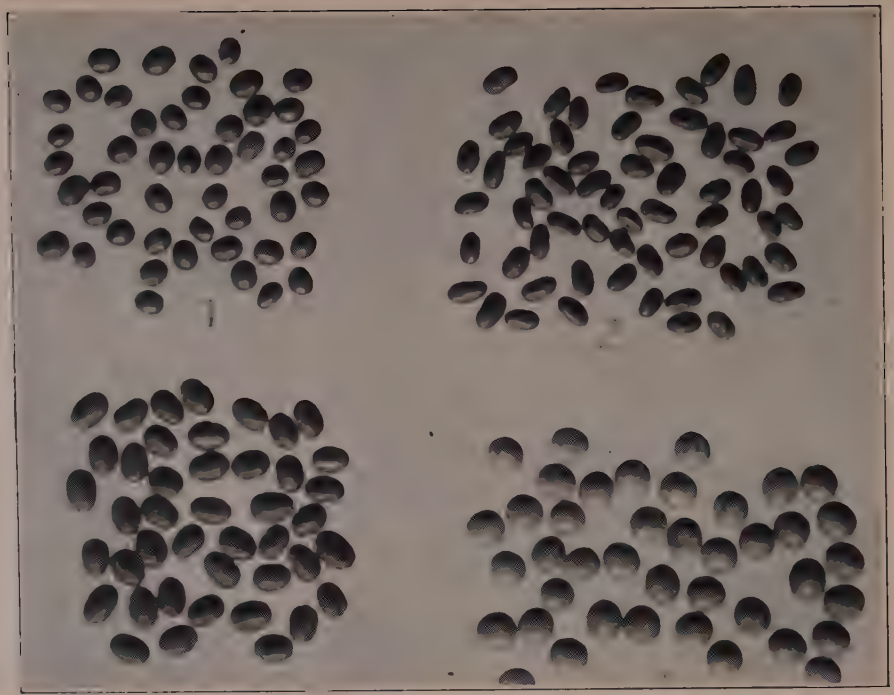

FIG. 40.—Standard varieties of soybeans: (1) Otootan, (2) Laredo, (3) Virginia, (4) Mammoth

lage. When used for ensilage with corn, soybeans are preferably sown in rows apart from the corn and mixed at the silo in the proportion of two to three loads of corn to one of soybeans.

Relatively little commercial fertilizer is needed for the crop where it is grown on good sod or corn land. Nitrogenous fertilizer has seldom given profitable results. The soybean seems to respond better to acid phosphate on soil well supplied with lime than to any other form. Probably the most common practice, when fertilizer is used, is to apply 300 to 400 pounds of acid phosphate and 50 to 100 pounds of muriate of potash to the acre.

*Analysis and uses*

As previously indicated, the soybean has a wide range of uses both in North America and in the Orient. Both the plant and the seed have considerable commercial value, the former being used as green-manure, forage, and pasture, while the seed affords soybean meal, soybean oil, and a great diversity of food products. Fresh soybean seed contains from 15 to 20 per cent of oil which is now being widely utilized in the manufacture of various industrial products such as explosives, enamels, varnish, paints, soap, inks, lubrication, celluloid, linoleum, edible oils and butter substitutes. The seed also furnishes valuable sources for food of special dietary value and for diabetics. Piper and Morse[1] compare the composition of soybean seed with that of other common legumes as shown in Table XXVI.

[1]Loc. cit., p. 106.

TABLE XXVI

COMPOSITION OF SOYBEAN SEED COMPARED WITH THAT OF OTHER LEGUMES

| Legume | Moisture, Per cent | Protein, Per cent | Fat, Per cent | N-free Extract, Per cent | Fiber, Per cent | Ash, Per cent |
|---|---|---|---|---|---|---|
| Soybean.... | 9.9 | 36.5 | 17.5 | 26.5 | 4.3 | 5.3 |
| Cowpea..... | 11.6 | 23.6 | 1.5 | 55.8 | 4.1 | 3.4 |
| Field pea.... | 9.2 | 22.9 | 1.1 | 57.8 | 5.6 | 3.4 |
| Navy bean.. | 13.4 | 22.7 | 1.5 | 53.0 | 5.8 | 3.6 |
| Horse bean.. | 12.6 | 26.2 | 0.9 | 49.4 | 7.1 | 3.8 |
| Velvet bean. | 11.7 | 20.8 | 6.4 | 51.0 | 7.5 | 2.6 |
| Garden pea. | 11.8 | 25.6 | 1.6 | 53.6 | 4.4 | 3.0 |

## CHAPTER XX

## *MISCELLANEOUS KINDS OF BEANS*

Several types of beans of minor commercial importance in North America will be treated here briefly not only because of their present limited uses but also because of their possible future value for culinary, forage, green-manuring, and ornamental purposes. Chief among these are the broad bean, velvet bean, Garbanzo or chick-pea, lentil, lupine, jack and sword beans, kudzu-vine, hyacinth bean, and carob or St. John's bread.

### BROAD BEAN *(Vicia Faba)*

This is one of the oldest types of beans recorded in history and is said to have been introduced into China nearly 3000 B.C. It is probably native in northern Africa and southwest Asia whence it has been introduced through the cooler temperate regions of the Orient and the Americas. It is not known when the broad bean was first brought to North America but records show it was introduced into southern California late in the nineteenth century. McKee[1] states that "in the United States practically the only use that has been made of horse beans is for vegetable purposes; and while they have been grown more or less for use in a green state,

[1] McKee, Roland. "Horse Beans." U. S. Dept. Agr. Farmers Bull. 969 (1918).

large commercial plantings have been made for the production of matured beans for use as a dry vegetable. However, some use has been made of them for stock-feeding purposes, and in some of the bean-growing sections of California they have been harvested by 'hogging down,' with very satisfactory results. The horse bean is of little value as hay, and stock do not seem to care for the stems and leaves in a green state; but in combination with corn and sunflowers it has been used quite successfully as silage."

Trials with this crop as a leguminous green-manure in the citrus regions of southern California have shown much promise, practically the only objection being the expense of seed. Recently the small-seeded variety, *V. Faba* var. *minor*,[1] has been introduced and because of the smaller volume of seed required in seeding, the above objection has been partly removed. According to the United States Census of 1920, the entire crop of horse beans is at present grown in California. This is reported as 49,694 bushels from 1,459 acres and having a value of $124,235.

*Climatic and soil adaptations*

The broad bean is one of the few types which are adapted to cool, temperate climates. Seed production is seriously curtailed by high temperatures during the growing season. It succeeds best in the Maritime Provinces of Canada and in the coastal areas of the Pacific Coast. The hardier varieties will withstand temperatures as low as 15° Fahrenheit. For this reason, the broad bean can be used as a winter cover-crop in regions of mild

[1]Kennedy, P. B. "The Small-Seeded Horse Bean, *Vicia faba* var. *minor*." Calif. Agr. Exp. Sta. Circ. 257 (1923).

winters. Farther north, it is seeded in the early spring as a vegetable and for stock-feeding purposes. Soil requirements are not exacting. Well drained moderately heavy soils are preferred. The broad bean is more tolerant of alkali soil than most other types of legumes. Inoculation is advisable when the soil to be planted has not previously grown this crop. The usual method of inoculation is recommended.

*Varieties*

Although many varieties are in cultivation throughout the world, only two are of importance in North America; the large-seeded variety Windsor, *V. Faba,* and the small-seeded variety, *minor,* previously referred to. The former is used to some extent as a vegetable purchased in dry-seed form by the poorer classes of Jewish and Italian peoples in larger cities. So utilized, it is commonly called "favas." The latter variety is employed mainly for soil-improving and stock-food purposes.

*Seeding*

Date of seeding depends on climatic limitations. In California, the summer crop is planted in February and March in the warmer regions and later in the cooler sections. This provides for the maximum of cool growing season available to a given locality. Planters for seeding lima beans can be used for the large-seeded variety, while the common bean or corn-planter is adapted for the small-seeded type. Much planting is also done by hand. The usual method of planting is in rows 30 inches apart with the seed 6 inches apart in the row. Seeded at this rate, about 125 pounds of seed are required to plant an acre.

*Harvesting*

Either hand or machine methods are used in cutting the crop. The drop-rake reaper is better than a mowing machine in that it leaves the cut plants in bunches, thus saving some labor and avoiding some shattering of the seed. Less shattering and loss of seed results if the crop is cut just before the uppermost pods are fully ripe. Considerable care must be exercised in threshing to avoid breakage of seed in the large-seeded variety. Bean-threshers with reduced cylinder speed are best. Under average conditions, yields averaging 1½ tons of seed to the acre are obtained.

## VELVET BEAN (*Stizolobium* spp.)

The velvet bean derives its common name from the fact that its seed is borne in large pods which are densely covered with pubescence, giving the latter a velvety appearance. It is apparently native to eastern and southeastern Asiatic countries whence upwards of twenty species have been introduced into the United States. According to Bailey[1], only three species have become prominent, these being described as follows:

Flowers dark purple: pods with velvety-black pubescence—*S. Deeringianum.*

Flowers dark purple: pods with appressed white pubescence—*S. Hasjoo.*

Flowers and pubescence of pods white—*S. niveum.*

*History and importance*

The velvet bean has been grown as an ornamental

[1]Bailey, L. H. "Manual of Cultivated Plants," p. 400. The Macmillan Company (1924).

vine for porches and trellises for more than forty years. Piper and Morse [1] state that "As early as 1890 this plant was used to some extent for green manure in citrus orchards in Florida. From that time until the present the acreage has increased rapidly, and the crop now occupies an important place in southern farming systems." It is probably the most vigorous-growing annual legume cultivated in the United States, producing a vine growth often thirty to fifty feet in length. Because of the long growing season required to mature seed of the earlier known varieties, cultivation was at first confined mainly to Florida. With the introduction and development of earlier varieties, culture has now extended throughout the corn- and cotton-belts of the South. According to the Bureau of Markets and Crop Estimates of the United States Department of Agriculture (Table XXVII), the acreage of velvet beans now planted exceeds 2,000,000 acres.

TABLE XXVII

VELVET BEAN PRODUCTION IN THE UNITED STATES (AVERAGE 1919-1921)

| Region | Acreage | Production (Tons) |
|---|---|---|
| Alabama | 779,000 | 749,000 |
| Georgia | 760,000 | 248,000 |
| Mississippi | 260,000 | 158,000 |
| Florida | 247,000 | 165,000 |
| Louisiana | 184,000 | 180,000 |
| United States | 2,466,000 | 1,631,000 |

*Climatic and soil adaptations*

This legume is essentially a warm climate crop, being

[1] Piper, C. V. & Morse, W. J. "The Velvet Bean." U. S. Dept. Agr. Farmers Bull. 1276 (1922).

originally adapted only to the Gulf states. Since the introduction of early varieties, a good growth of plants and fair yields of seed can be obtained as far north as the Ohio River. In the Gulf states the velvet bean is becoming increasingly important as a winter annual to supplement corn for forage purposes. It is well adapted to the sandier less fertile soils, making good growth on newly cleared woodland. For this reason and the fact that it produces such an abundance of organic matter, its greatest value lies in use as a soil-improving crop. Artificial inoculation of the soil has generally been unnecessary throughout the territory adapted to velvet bean production.

*Varieties*

The first variety long produced in Florida and elsewhere for ornamental as well as economic purposes was named Florida. This is of the species *S. Deeringianum* described above as having dark purple flowers and pods with velvety-black pubescence. The seeds are grayish, marbled with brown, nearly spherical and about three-eighths of an inch in diameter. The Florida velvet bean will not yield a profitable crop of seed more than 200 miles north of the Gulf Coast, hence its cultivation has not been extended throughout the cotton-belt. An early-maturing variety named Georgia was selected from the Florida type and later the variety Alabama was similarly discovered. These varieties mature seed in 110 to 130 days, hence are widely adapted throughout the cotton- and corn-belts of the South. They are sometimes named Early Speckled or Hundred-Day Speckled and differ from Florida mainly in respect to earliness.

Some promising varieties have been recently intro-

duced by the United States Department of Agriculture; namely, Lyon, from the Philippine Islands in 1907; Chinese, from China in 1909; and Yokohama, from Japan in 1909. Several hybrids have been developed from the above varieties at the Florida Experiment Station[1]. The variety, Osceola, is the only one of these which is much grown. In this breeding and improvement work, effort has been made to increase earliness, to lessen the tendency to shatter seed, and to increase yield. A bush or bunch type has been selected as a sport from Florida. This non-twining habit of growth has made the variety popular for orchard green-manure purposes and for growing with corn when the twining habit is not desired.

*Fertilization and planting*

Very little fertilizer, if any, is generally applied. When used, the mixture and quantity is about the same as for corn. No increase in yield of beans was obtained from the addition of fertilizer of any kind in a test at the Florida Experiment Station. On the basis of a test in 1916 at the Mississippi Station, the application of 100 to 200 pounds of acid phosphate to the acre is recommended. No increase from the addition of cotton-seed meal or animal manure was obtained.

Since velvet beans do not germinate well in cold soil, they should not be planted until the soil is warm and all danger of frost is past. This is usually about cotton-planting time. Early seeding is important, however, when late varieties are used and when the growing season is limited. Being twining plants, velvet beans require

[1]Scott, John M. "Velvet Bean Varieties." Fla. Agr. Exp. Sta. Bull. 152 (1919).

a supporting crop. Most of the acreage is now planted with corn, the beans being placed either in the row with corn or in separate rows between the rows of corn. Depending on earliness of the corn variety and date of planting, the yield of ear corn may be decreased by competition with the beans. For this reason, it is sometimes advisable to plant the corn several weeks before the beans. When yield of corn is of first importance, from 2 to 3 quarts of beans an acre are seeded; if large yields of beans are wanted, twice as much seed should be used. The usual rate of seeding for green-manure purposes is ½ to 1 bushel to the acre.

*Harvesting and threshing*

Because of the tangled nature of the mature plant, the seed-pods are necessarily harvested by hand-picking. From 25 to 50 cents the hundred pounds is the usual wage paid for this work. When the corn and beans are to be harvested by hogging-down, only sufficient beans for the following year's seed supply are picked. About one ton of beans in the pod is considered an average yield. One hundred pounds of pods will shell about 60 pounds of beans. Thorough maturity of the pods is essential to the proper curing and keeping of the threshed crop. Special bean-hullers are available for threshing large crops, while smaller lots are usually threshed with the flail.

*Uses*

A great variety of uses can be credited to the velvet bean. Originally, it was used only as an ornamental vine for trellises and porches. Later, it became a popular green-manure crop in the citrus orchards of Florida.

At present, its greatest value lies in its use as a soil renovator on the less fertile sandy soils of the corn- and cotton-belts of the Gulf states and as a highly nutritious forage and grain crop in these regions. It makes an even greater growth of forage than cowpeas, is not attacked by nematodes and holds its leaves after maturity better.

Two factors largely responsible for its rapid increase in production in recent years were the development of earlier maturing varieties and its use as a substitute cash crop in case of cotton failures due to the boll weevil. Velvet-bean meal, made by grinding the pods and seed together, contains over 20 per cent of crude protein, about 55 per cent of digestible carbohydrate and about 4.5 per cent of fat. As a feed for live-stock, it, therefore, fills an important place in southern agriculture.

### GARBANZO OR CHICK-PEA (*Cicer arietinum*)

This is an annual legume which grows to a height of 1 to 2 feet, is erect, branched, and with leaves made up of 9 to 15 pubescent leaflets. Only 1 to 2 seeds are borne in each pod, the pods being ¾ to 1 inch long and ½ inch broad. The seed is about ¼ inch in diameter, wrinkled, usually white. The Garbanzo is native to western Asia but has been cultivated in Mediterranean countries since ancient times. Spain and Mexico produce most of the supply now in the world markets. Somewhat over 2,000 acres are grown annually in the Sacramento Valley of California. The dried beans are utilized mainly by Latin peoples in large cities, either in the boiled or roasted form. Much of the California and the imported crop is exported to Mexico, Cuba, and South and Central American countries.

According to Hendry[1], the Garbanzo is adapted to a wide range of temperature but has shown a preference for the coast regions of California. There, the principal causes of failure are poorly drained soil and insufficient length of growing season. About the same method of planting and amount of seed to the acre is used as with the commn kidney varieties. Yields of 1,000 to 2,000 pounds to the acre are commonly obtained.

### LENTIL (*Lens esculenta*)

Historical and biblical writings make frequent mention of the lentil as a prominent article of food among the peoples of south and west Asiatic and Mediterranean countries. There it is prepared in numerous ways, while in America its most common use is in soups. It is a popular food among Latin people in North America but is not grown at all commercially. Most of the supply in commerce is produced in southern Europe.

The plant is a short-season branched annual legume reaching 10 to 18 inches in height. The pod is ½ to ¾ inch long and about as broad, bearing two dark green or brown seeds convex on both sides. Germination is hypogeal.

### LUPINES (*Lupinus* spp.)

Most of the common species of lupine are annual, those mosta commonly grown being white (*L. albus*), yellow (*L. luteus*), and blue (*L. hirsutus*). These produce plants from 1 to 4 feet tall with hairy leaves and flowers corresponding to the above colors. Since ancient times, lupines have been grown and used in Mediter-

[1]Hendry, G. W. "Bean Culture in California." Calif. Agr. Exp. Sta. Bull. 294, p. 25 (1921).

ranean countries for soil improvement, fodder, and human food. Sufficient of the seed is now imported by the United States to supply the demand of Mediterranean peoples in larger cities. The seed containing a relatively high content of poisonous alkaloids requires long soaking in water to remove the bitter element. Many species occur wild over the plains area of North America. Marsh, Clawson and Marsh[1] report instances of lupine or "loco" poisoning, particularly in sheep and cattle pastured on range land in Montana. Care to avoid range land containing much lupine is, therefore, necessary. Pastured or fed as hay in moderation, lupines are a valuable source of fodder. Horses especially relish both the green plants and the cured hay.

### JACK BEAN (*Canavalia ensiformis*)

This is a bushy semi-erect annual legume which grows to a height of 2 to 4 feet, becoming more or less twining under tropical conditions. The flowers are purple. The large pure white seed with a brown hilum is very attractive and for this reason the jack bean has been frequently exploited under different names through extensive advertising. The seed-pods are 9 to 14 inches long and each contains 10 to 14 seeds. A native of the West Indies, its cultivation is mainly confined to this region. Piper[2] states that the jack bean is adapted to about the same conditions as cotton, that it is easy to grow, very drought-resistant, and that its pods will mature occasionally at least, as far north as Washington, D. C.

[1] Marsh, C. D., Clawson, A. B., and Marsh, Hadleigh, "Lupines as Poisonous Plants." U. S. Dept. Agr. Dept. Bull. 405 (1916).

[2] Piper, C. V. "The Jack Bean." U. S. Dept. Agr. Dept. Circ. 92 (1920).

The crop is best grown in cultivated rows about 3 feet apart, the plants 6 to 12 inches apart in the row. About 1 bushel of seed is required to plant an acre. Yields of 10 to 20 tons to the acre of green forage and 20 to 50 bushels of seed have been reported by various experiment stations. Its principal uses are as green-manure, green feed, hay, ensilage, green pods or seeds for food, ripe seeds for food or feed and the extraction of urease for medicinal purposes. Tests conducted in the southern states indicate that the jack bean is not as well suited for green-manure and forage purposes as either the velvet bean or the cowpea. In Malaysia and the West Indies, however, it is extensively used for these purposes. As a green feed, the jack bean has not proved wholly successful because of its more or less bitter taste. Although in dried form the plant is rather too coarse and woody to make good hay, there is some promise that it will make ensilage suitable for stock feeding. When the young pods are only 4 or 5 inches long, they may be used as a vegetable substitute for snap-beans although they show a tendency to become tough beyond this stage of maturity. The ripe seed when ground into meal is not so readily eaten as the velvet bean. Altogether, in spite of its easy cultivation and large yields, it is not likely soon to become an important crop in North America.

### SWORD BEAN (*Canavalia gladiata*)

Unlike the jack bean with which it is often confused, the sword bean is trailing in habit of growth. Its pods are of about the same length, 10 to 12 inches, but somewhat wider, 1½ inches. The seeds are also larger, being ¾ to 1 inch long, very flat, usually red, pink or brown in color with a narrow hilum running almost its entire

length. It is native to oriental countries, most of the crop being grown in tropical climates where it is extensively used as human food.

### KUDZU (*Pueraria hirsuta,* or *Phunbergiana*)

Probably no legume grown in North America is better adapted for the ornamentation of arbors, porches and wells than the kudzu-vine. Being strictly of a vining habit, it is commonly grown for this purpose in southern cities where favorable conditions of support are available, the plant often climbing to a height of 50 to 75 feet. The leaves are very large, angular lobed, the flowers purple and borne in short clusters. According to Piper [1] the kudzu is native to Japan. The Japanese use it extensively for pasture and also its starchy roots to make certain articles of food. Very little utilization of the plant has been made in the United States, but Piper states that it shows most promise as a pasture plant. Horses and cattle eat it greedily. Under field conditions it sends out prostrate branches which take root at the joints, from which arise ascending twining branches, the whole making a dense mass of herbage.

As a rank growing perennial, maximum yields of herbage are not obtained until about the third year after planting. Seed is expensive, seeding unsuccessful, hence propagation is mainly by root-cuttings and transplanted plants, the plants being set about 10 feet apart. Heavy soils are better adapted to the successful growth of kudzu than are light soils. Chemical analyses indicate that it is very nutritious, being comparable to clover and alfalfa.

[1] Piper, C. V. "Kudzu." U. S. Dept. Agr. Dept. Circ. 89 (1920).

### HYACINTH BEAN (*Dolichos Lablab*)

The hyacinth bean is often referred to as Lablab, the Egyptian name originally applied to it by Linnæus, and as bonavist. It is a native of India, is commonly grown and utilized in tropical and subtropical Asiatic countries much as snap-beans and has been spoken of as "the kidney bean of the Asiatics." In the more temperate regions, notably in the United States, its purple-leaved floriferous varieties are used as ornamentals over trellises and porches. To a limited extent, it has been employed for forage and green-manuring.

In growth habit, the plant varies from dwarf bush to strictly vining forms, the latter sometimes reaching 30 feet in length. The leaves are very broad-ovate, 3 to 6 inches long and often fully as broad. There are both white- and purple-flowered varieties, the seed color usually corresponding to the flower color. The pods vary greatly in size and color also, but most commonly resemble pods of the dwarf sieva limas. They are 1 to 2½ inches long, close-pubescent or smooth and either straight or curved.

Piper and Morse [1] refer to the close resemblance of the hyacinth bean to the cowpea, stating, however, that it is more vigorous and more viny. Quoting these authors further, "the best bushy or half-bushy sorts planted in 3-foot rows make much the same type of growth as the cowpea and under the same conditions will produce a greater yield of hay, which is more easily cured, owing to its smaller moisture content. The plants are markedly drought-resistant, and . . . suffer less from drought

[1] Piper, C. V., and Morse, W. J. "The Bonavist, Lablab, or Hyacinth Bean." U. S. Dept. Agr. Dept. Bull. 318 (1915).

than cowpeas. The bonavist is also well adapted to planting with corn or some other supporting crop. In corn the vining habit . . . becomes accentuated, and some of the more vigorous varieties will grow across the rows, making a tangled mass difficult to handle when cutting for silage. The principal weakness of the bonavist, considered as a forage crop, is the relatively poor yield of seed and the difficulty of harvesting the same, which makes it expensive."

### CAROB (*Ceratonia Siliqua*)

The large, dry, brown, flattened, sweet-tasting pods common in the Italian and Greek fruit-stands of larger cities and sold under the name of St. John's bread are more or less familiar to the traveling public. This bean grows on an evergreen tree native to east Mediterranean countries and now widely cultivated in subtropical regions for its edible pods. The tree reaches a height of 40 to 50 feet, bearing red or yellowish flowers which develop fruit-pods from 4 to 12 inches in length. The pods containing 30 to 40 per cent sugar are prized as human food and are used either in the dried raw form or cooked.

According to Condit,[1] the California Agricultural Experiment Station propagated the plant and distributed seedlings for cultivation in southern California about 1878. Previous to that time, the United States Patent Office had made importations for trial from Spain in 1854 and from Palestine in 1859. The carob in North America is now grown mainly in the more arid regions of California. It is drought- and alkali-resistant but

[1]Condit, I. J. "The Carob in California." Calif. Agr. Exp. Sta. Bull. 309 (1919).

very susceptible to freezing injury in its seedling stage. Propagation is mainly by seedlings grown from seed specially soaked and germinated in warm, moist, sandy beds. The carob is grown in southern California for ornamental and shade tree purposes. Experiments have shown the adaptability of the bean and pod for fattening cattle when prepared as carob bean meal. In this form it contains approximately 7 per cent protein, 2 per cent fat, 30 per cent sugar, 40 per cent carbohydrate other than sugar and 9 per cent crude fiber. Probably most of the St. John's bread in the markets is imported.

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